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WEEKLY November 21 - 27, 2015

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The people who never forget a face

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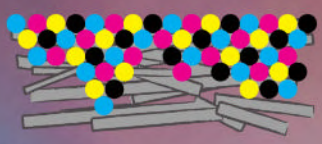

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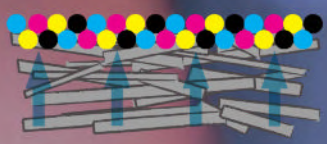

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CONTENTS

Volume 228 No 3048

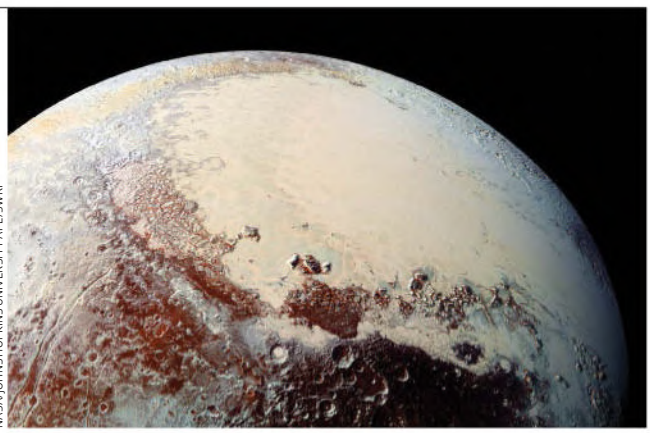
This issue online
newscientist.com/issue/3048

News

8

World of the ice zombies

Pluto is frozen yet mysteriously active – but how?



NASA/JOHNS HOPKINS UNIVERSITY APL/SWRI

On the cover

30

Gut thinking

The surprising ways food controls your mind

Cover image
Westmac

9 **That's no moon**
Our neighbour is a planet
12 **Super-recognisers**
The people who never forget a face
38 **Chip off the old block**
Silicon is dead. Long live silicon!
14 **The curse of Yarumal**
Alzheimer's in Colombia
34 **Into the twilight zone**
Pluto's final mission

Features

38

Chip off the old block

Silicon is dead. Long live supersilicon!

SPENCER WILSON

Coming next week...

Hold that thought
How memories make us

Greening the dragon
China's surprising climate clean-up

rbi reed business information

recycle
When you have finished with this magazine please recycle it.

Leaders

5 Ecosystems need economic arguments. Resilience means bouncing forward, not back

News

6 **UPFRONT**
Paris: the psychological aftermath. Cure for frog-killing fungus. Australia flood warning. Disability suicides. Pesticides harm pollination
8 **THIS WEEK**
The moon's a planet. Reintroducing beavers to the UK. Algorithm to attack P versus NP. Pigeons diagnose breast tumours. Are you a super-super-recogniser? Bird's gene-flip mating trick. How Alzheimer's came to Colombia. Anti-booze drug hints at HIV cure
16 **IN BRIEF**
Fairness shaped by culture. Origin of Earth's water. Greenland glacier melting fast. Ants use heads as doors. England's antibiotics hotspots

Technology

20 Computers that zap our brains. Tracking elephants by their rumbles. Controlling computers with silent speech

Aperture

24 Insect lovers share an insect meal

Opinion

26 **Up in flames** Malawi's situation shows carbon pledges can fail, says Roger Harrabin
26 **Africa's deficit** We're missing a valuable resource in climate talks, says Curtis Abraham
27 **One minute with... Jess Thom** I embrace the spontaneity of living with Tourette's
28 **Not as we know it** Alien life is likely to be very different from us, says Steven Benner

Features

30 **Gut thinking** (see above left)
34 **Into the twilight zone** New Horizons probe embarks on its final mission
38 **Chip off the old block** (see left)

CultureLab

42 **Computer says no** Automation is about to take over the professions. Will they survive?

Regulars

52 **LETTERS** Scientifically illiterate politicians
56 **FEEDBACK** Dirty dishes of mindfulness
57 **THE LAST WORD** If the moon vanished...

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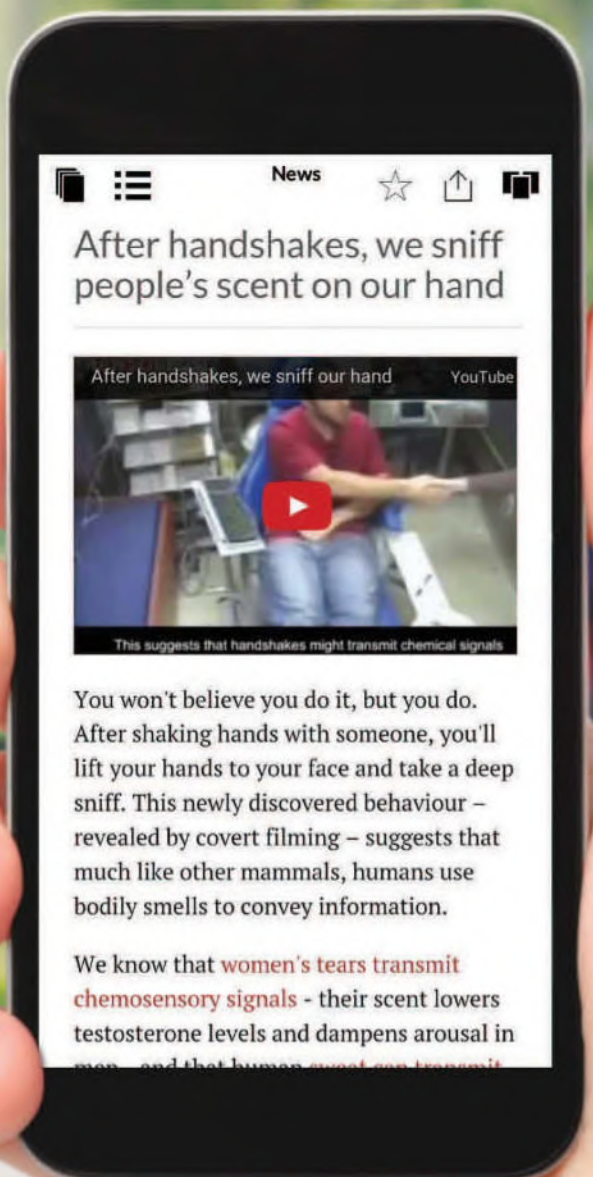

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IGNACIO YUFERA/FLPA/MINDEN

Out of the wilderness

Ecology and economics have been separated for too long

OIKOS. The Greek word for home is the root of both "ecology" and "economics". But the two subjects parted ways long ago, and for much of the 20th century their students paid little heed to each other. In the 21st, however, it is obvious that they are inextricably linked. Ecological economics is now securely on the curriculum at universities around the world.

Conservationists have learned that support is easier to garner when fuzzy sentiments are backed up with hard numbers: talking up the value of "natural capital" and "ecosystem services" has proved effective in areas such as forestry and flood protection.

But ecological economics is still more of an academic pursuit than a practical one. Attention has recently turned to "rewilding" – returning formerly native flora and fauna to their prior range. The idea is popular, particularly among urbanites who thrill to the idea of a wilder countryside.

Those who actually work there are often less enamoured. Big predators such as the wolf, bear and lynx are not welcome: farmers across Europe fear for their flocks and herds. And even the return of herbivores such as the beaver is resisted, some arguing that it will harm rural livelihoods (see page 10).

How to strike a balance? The emotional argument revolves around competing ideas of what is "natural". That is a question of timescale: many countryside icons are alien if you go back far enough, from rabbits and fluffy white sheep to the grassy hills they graze on. And their presence often depends on subsidies.

The economic argument centres on the costs of dead livestock and unproductive land. Those are fair concerns, but the other side of the cost-benefit equation is often missing. For example, predators keep down deer and fox numbers; and beavers can protect farmland and boost fisheries.

We have a duty to fix battered ecosystems. But if we are to make progress, we must consider ecology and economics as two sides of the same coin. After all, we need both to make a home. ■

Bouncing forward

MORE than a fortnight after a bomb brought down a jet over Sharm el-Sheikh, there are still holidaymakers waiting to be evacuated. The problem is not the supply of planes, it's the stricken airport's ability to deal with them.

Resilience is high on the agenda for planners everywhere: our complex societies are vulnerable to cascading failures. The effects can be similar whatever the cause. Borders may be left impassable by a pandemic (as when Ebola struck Africa), terrorism (as in France last week) or disaster (volcanic ash across Europe in 2010). There may be similar responses, too.

Resilience is often taken to mean "bouncing back". That is, of course, fervently to be hoped for when it comes to individuals who endure such atrocities as the Paris attacks (page 6).

But when it comes to essential infrastructure, bouncing back is not enough. At a recent resilience event, the talk was of "bouncing forward" – not just rebuilding the status quo, but future-proofing at the same time. For example, we might formalise the *ad hoc* use of social media to offer succour.

That's the spirit in which we should pick ourselves up after whatever setback comes our way. Because sadly, the many threats to our societies are not going away any time soon. ■

PHILIPPE WOJAZER / REUTERS

Now to help the survivors

IN THE wake of last week's terror attacks in Paris, which killed at least 129 and injured hundreds more, thoughts are turning to the survivors and how to prevent them experiencing long-term health problems. The world's top psychiatrists have come up with a five-point plan to help.

Research suggests that between 70 and 90 per cent of people exposed to trauma will cope effectively on their own. However, a small number may experience post-traumatic stress disorder (PTSD). "People are very resilient," says Chris Brewin of University College London, who helped develop a programme to aid survivors of the 2005 terrorist attacks in London.

In 2007, the world's top psychologists drew up a five-point plan for helping communities deal with traumatic events. "It's evidence-inferred, because with terrorist acts there are no randomised controlled trials to back things up scientifically," says Brewin. "But there is evidence, and the strategy was put together by the most experienced trauma people in the world," he says.

The first priority is safety: taking visible steps to make terror attacks less likely. The second is to keep people calm. "People generally calm down of their own accord provided they're not kept in a state of anxiety by events elsewhere," says Brewin.

The third, crucial, factor is connectivity – the ability to contact loved ones to tell them you are safe. Fourth is feeling that the community is there to help if needed.

The final factor is hope, particularly to repair the "shattered world views" that often accompany major terror events. "Given the right support, what is amazing is that even in the worst conditions, the majority of people don't develop debilitating symptoms," says Arieh Shalev of the New York University School of Medicine, and a co-author of the 2007 strategy.

The French authorities should definitely avoid early debriefing of the people who witnessed the massacre first-hand, to help them come to terms with their experiences. Evidence suggests such intervention does more harm than good. "You don't want to override people's own coping systems," says Brewin. Instead, he says, they should follow up with people in three months' time and offer professional help to those who are not recovering on their own.

Amphibians cured

HELP is at hand for toads and their kin. Scientists have successfully eliminated the amphibian-killing chytrid fungus from sites in the wild for the first time.

Since emerging in the 1980s, chytridiomycosis, caused by the fungus, has affected hundreds of amphibian species on five continents, causing population crashes and local extinctions.

In Mallorca, Spain, a species of midwife toad found only on the island became threatened when a captive breeding programme brought the deadly fungus with it. Researchers have now managed to eliminate the disease from four out of five pools tested there.

They did so by catching tadpoles and treating them with antifungal drug itraconazole. Before releasing the treated tadpoles, they also applied chemical disinfectant to the ponds. The ponds have remained chytrid-free for two years (*Biology Letters*, DOI: 10.1098/rsbl.2015.0874). "It is a bit of a turning point because it shows we can do something about the pathogen," says study author Trenton Garner at the Institute of Zoology in London.

"It's the first elimination of the amphibian-killing chytrid fungus from sites in the wild"

Dirty drone?

IS RUSSIA attempting a *Dr Strangelove*? A secret military document leaked on Russian TV this month revealed plans for a long-distance underwater drone carrying a nuclear bomb designed to dump high levels of radioactive contamination when it reaches foreign shores, using a design mooted in the classic 1964 film.

Analysts suspect the leak was deliberate – and aimed at US efforts to develop missile defences, something Russia has

been worried about for years. It is not possible to determine whether Russia is developing the system, or merely threatening to, never mind whether it can build anything as ambitious as the specifications in the document.

Some are alarmed that Russia's highest command is even talking about such a weapon – and then letting us know about it.

"If it's a deliberate leak, it's extraordinarily provocative," says Daryl Kimball, head of the Arms Control Association in Washington DC. "I am deeply concerned about who is in charge and whether they have any sense of restraint."

Benefits suicides

A CRUEL false economy? UK government efforts to reduce the number of people claiming disability benefit appear to have driven 590 people in England to suicide and to have put 725,000 more on antidepressants.

Since 2010, more than a million people have had their eligibility for disability allowance reviewed.

Now, a statistical analysis of mental health indicators and other factors in 149 local authorities has found that the number of disability benefit reassessments in each area between 2010 and 2013 is linked with rises in suicides, antidepressant prescriptions, and in people reporting mental health problems for the first time (*Journal of Epidemiology & Community Health*, doi.org/892)

"It's likely the uncertainty affected the health of even those who were allowed to retain disability benefits"

Team leader Ben Barr at the University of Liverpool says the uncertainty of the process is likely to have affected even those who were allowed to retain benefits.

Aussie flood alert

PREPARE for rain. Queensland could face devastating floods in just over a year's time, rivalling those seen in 2010-11, as the effects of climate change and an impending La Niña weather event combine.

The 2011 floods were some of the worst seen in Australia in a century, killing 35 people and causing A$2.5 billion (US$1.8 billion) of damage. The effects of climate change made the severity of the rains, brought by that year's La Niña, even more likely (*Geophysical Research Letters*, doi.org/89x). "Long-term ocean warming made this event three times as likely as it would have been without the warming," says Caroline Ummenhofer of Woods Hole Oceanographic Institution in Massachusetts.

La Niña brings warm ocean water to Queensland, and with it comes rain. The world is currently in the grip of an extreme El Niño, which usually flips within a year to become a La Niña.

An extreme La Niña may develop by this time next year, says Wenju Cai of Australia's CSIRO research organisation in Canberra. "It is highly likely that January 2017 could see floods similar to those in 2011." Ummenhofer agrees this is a worrying possibility.

Neonicotinoids blunt pollination

HOW do you like them apples? Apple trees pollinated by bumblebees exposed to neonicotinoid pesticides contained 36 per cent fewer seeds than those pollinated by unexposed bees.

The results are the first to show that neonicotinoids impair the insects' ability to pollinate plants. Previous studies have found that the controversial pesticides can affect bees, but haven't measured how that then translates to their pollination services.

About 30 per cent of agricultural crops depend on pollination by animals, with an estimated global value to farmers of $360 billion per year. "Our work highlights the importance of pollination services, and including that in the debate about whether to ban or restrict neonicotinoids is very important," says Dara Stanley of Royal Holloway, University of London.

Stanley and her colleagues exposed colonies of bumblebees to nectar that either contained neonicotinoids at levels typically found in wild flowering plants, or none at all. The bees exposed to neonicotinoids collected less pollen from apple trees and visited apple flowers less frequently than the other group (*Nature*, DOI: 10.1038/nature16167).

This behaviour resulted in a reduction in the number of seeds found in apples, an important indicator of the extent of pollination.

VICTORIA WICKENS

Not as busy as I seem...

60 SECONDS

Rover to play in sand pit

NASA's rover Curiosity is set to spice up its journey around the Red Planet with a trip to some active sand dunes. The rover is about 200 metres away from the Bagnold dunes, which are thought to creep across the surface of Mars by about a metre each year, and should arrive in the next few weeks to scoop sand samples and take other measurements.

Polar bear on thin ice

They aren't just a symbol of climate change – they're true victims, fleeing their preferred sea ice habitat which has become sparser each summer. In the Chukchi Sea, north-west of Alaska, polar bears spent 30 more days a year on land from 2008 to 2013 than between 1986 and 1995. (*PLoS One*, DOI: 10.1371/journal.pone.0142213).

Quantum buy

The US Los Alamos National Laboratory has bought a D-Wave quantum computer to research advanced computing techniques. Lockheed Martin and Google have already bought D-Wave machines, thought to cost around $15 million, but there is no definitive evidence they can outperform ordinary computers.

Tantalising water

Our planet is hiding huge amounts of groundwater inside its crust, enough to submerge the surface by 52 metres. But it seems we can only tap into a tiny proportion of the water. Just 1.5 per cent is accessible for use (*Nature Geoscience*, doi.org/89w).

Ebola over?

A baby boy who has recovered from Ebola is thought to be Guinea's last Ebola patient. The 19-day-old boy left a treatment centre earlier this week. Guinea is the last country still fighting Ebola, and if no new cases appear in the next 42 days, the outbreak will be declared over.

Pluto, king of the ice zombies

Our favourite dwarf planet hints at an outer solar system full of frozen yet active worlds

Joshua Sokol, National Harbor, Maryland

ADD a note to the edge of a map of our solar system: here be ice zombies.

Before NASA's New Horizons probe flew past Pluto in July, those behind the project were worried that the dwarf planet would be boring.

"In your worst nightmare, you convinced NASA to go all the way to the end of the solar system and you would have a cratered ball,"

"Far from being frozen solid, a circulatory system of slush might be keeping Pluto frosty but undead"

says team member Bill McKinnon of Washington University in St Louis.

Thankfully, Pluto played along. The fly-by showed that the dwarf planet is more alive than anyone predicted, full of weird geology from glacier-carved valleys to broad mounds that look like ice volcanoes. Last week, planetary scientists began to share their first guesses about these features' origins at a meeting of the American Astronomical Society's Division for Planetary Sciences in National Harbor, Maryland.

But as they work to understand how the pieces fit together, two questions linger: what powers Pluto? And will other worlds in the cold reaches of the outer solar system be the same?

Even by themselves, the signs of recent geology on Pluto are giving us plenty to puzzle over. While some areas look dead and scarred by aeons of craters, the west side of Pluto's famed heart feature sports not a single blemish (see photo, right). The lack of craters means that the region, a glacial field of frozen nitrogen and carbon monoxide called Sputnik Planum, has repaved itself with fresh ice within the last 10 million years. But how?

The round centre of Sputnik Planum may be a basin hollowed out by an impact billions of years ago, New Horizons team member Paul Schenk argued at the meeting. Later, the cavity was filled either as ices settled out of the atmosphere, or oozed out as a slushy lava from the crust.

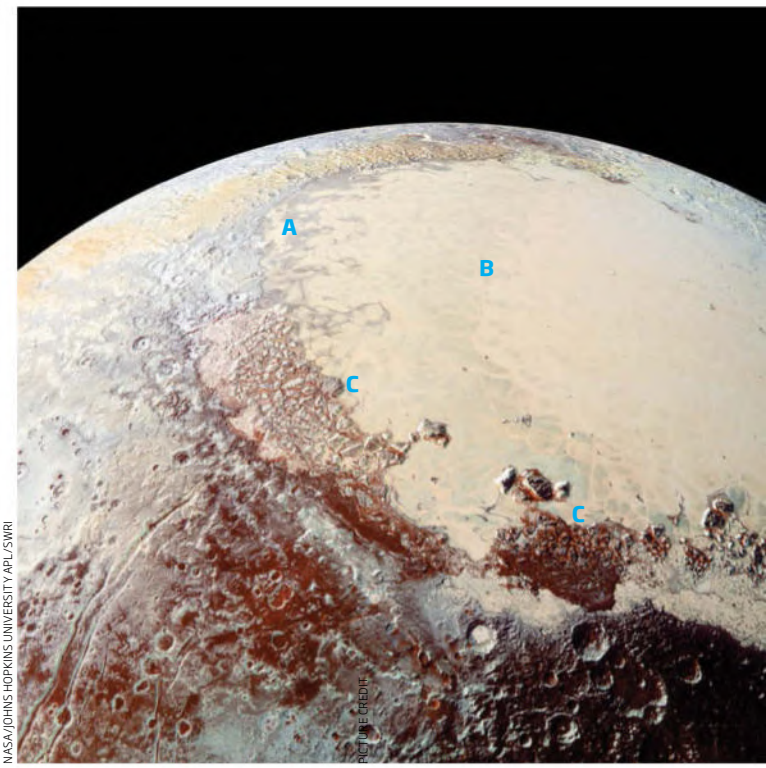
A range of jagged mountains on the west edge of Sputnik Planum could be blocks of water ice that were released from the crust beneath the basin when it was cracked open during the impact. They may have floated to the top of denser nitrogen ice and collected in a logjam at the basin's edge, the team says.

Giant polygons that rise a few tens of metres above the Sputnik plains may be rising bubbles of soft nitrogen ice, perhaps from a few kilometres below – maybe even warmed up or melted at that depth. "There's this churning cauldron of the volatile ices," McKinnon says. The ices may even evaporate into the atmosphere, fall as snow on the surrounding peaks, and slide into the basin as glaciers, McKinnon says.

The most dramatic signs of recent geological activity are the two putative volcanoes, Wright and Piccard Mons. Each is a few kilometres tall and about a hundred kilometres wide. With depressions at their tops and nubby deposits on their slopes, both look like they were built where material – mysteriously heated from underneath – has been coming to the surface.

But the mountains are too fat to be made of firm water ice, and too sharp to be made of pliable nitrogen ice. "If it's volcanic, it's a new kind of construct," McKinnon says. "Maybe it's something more interesting, like ammonia in water ice or methanol."

That sort of mixture might be the key to explaining not just Pluto's volcanoes, but its overall activity. Pluto is small, just one-third the volume of our moon, which limits the heat it could hold on to since its formation. It also has no giant planet nearby to build up warmth by tugging at its



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SEPARATED AT BIRTH?

Pluto's long-lost sibling from the outer solar system could have been under our noses the whole time.

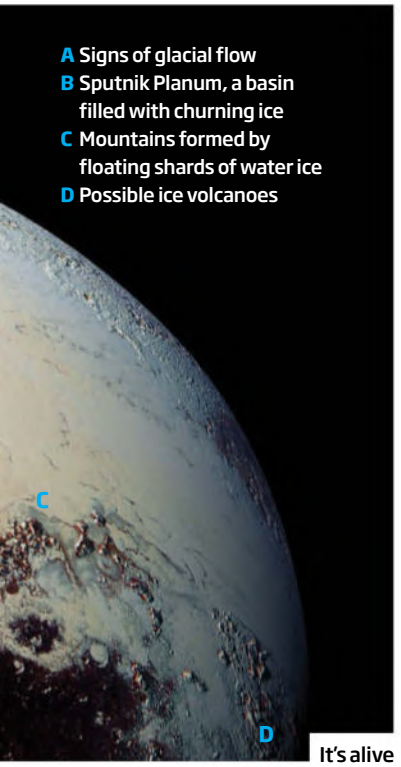
The asteroid belt-dwelling dwarf planet Ceres has ammonia baked into the clays on its surface, according to research from NASA's Dawn mission presented at last week's Division for Planetary Sciences meeting. Models predict that the asteroid belt is too warm for ammonia, so that could mean Ceres originated in the same neighbourhood as Pluto.

Previously, Bill McKinnon of Washington University in St Louis argued that Ceres has more water than other asteroids, so it may have moved in from the outer solar system.

Now Carle Pieters of Brown University in Rhode Island argues that Ceres's surface can be best explained by minerals with ammonia locked in. That ammonia could date back to a time when Ceres, fresh from colder climes, still had ice on its surface, which boiled off once it was dragged closer to the sun.

"It would have been spectacular for a while - the ultimate comet," McKinnon says.

In this section
- Reintroducing beavers to the UK, page 10
- How Alzheimer's came to Colombia, page 14
- Computers that zap our brains, page 22



It's alive

insides, like Neptune's gravity does to its moon Triton.

For Sputnik Planum to stir like we think it does, Pluto must have found a way to stretch its meagre heat budget. One idea presented at the meeting is that Pluto's water ice is spiked with something that acts like antifreeze: ammonia.

Antifreeze

Though water ice is frozen so solid it acts like rock on Pluto, an infusion of ammonia, which is abundant in the outer solar system, can make it melt at much lower temperatures. That could let the material under Pluto's crust churn, with hotter, liquid ice rising to the top, says Alex Trowbridge of Purdue University. "Once you start getting melt, that decreases the viscosity and allows things to flow much easier," he says.

That could give Pluto life without needing much heat. "If that material is low viscosity, it doesn't have to be really warm," says Michael Bland of the US Geological Survey. Far from being frozen solid, a circulatory system of slush might be keeping Pluto frosty but undead.

Surprised that geology on Pluto has somehow defied the cold, Bland and others are now curious about the other lone dwarf planets out there.

"The common conception is that they don't have enough energy to drive geologic activity into the present day," Bland says. But visiting Pluto has proved that idea wrong. "The interesting thing is: if that's true on Pluto, what are the implications for other bodies in the solar system as well?"

The rest of the dwarf planet family gives plenty of food for thought. Some might be less active: Eris is even colder, and doesn't have much atmosphere, and thus might not have glacial transport. Haumea has far fewer volatile ices. On the other hand, Makemake and others might move in a similar way to Pluto. "Makemake is like Pluto's cousin with much more methane," McKinnon says. We might even be exploring another long-lost member of the family right now (see "Separated at birth?", left).

The outermost regions of the known solar system have also just acquired another likely dwarf planet: V774104. Discovered by Scott Sheppard of the Carnegie Institution in Washington DC, and presented to the meeting, not much is known about the new world – except that it is roughly half the size of Pluto and about three times as far from the sun.

"What Pluto has shown us is that the object itself is generating the activity, and there's no reason that many of the others, maybe all of the others, shouldn't do the same," says New Horizons team leader Alan Stern. New Horizons is already aimed at another distant body (see "Beyond Pluto", page 34), which is probably too small to be alive. But who knows about its larger cousins? "We really need to go find out," Stern says. ■

Moon could be a planet under new definition

WHEN is the moon not a moon? If a new proposal for defining planethood is adopted, the moon could be considered a planet in its own right.

The meaning of the word "planet" has been a sore point since 2006, when the International Astronomical Union (IAU) adopted a definition of a planet as being more or less round, and massive enough to have accreted or flung away objects in its orbital neighbourhood.

Famously, this excludes Pluto, recently revealed to be a stunningly complex world (see story, left).

Even astronomers who are largely happy with Pluto's dwarf-planet status have misgivings about the definition. The criteria are vague, and refer only to our solar system – excluding the thousands of worlds detected around other stars since the definition was written.

"I want a classification that applies both to the solar system and to exoplanets," says Jean-Luc Margot at the University of California, Los Angeles.

Margot has now proposed a mathematical definition, which he outlined at the recent meeting of the Division for Planetary Sciences meeting in Maryland. "I wanted it to be rigorous and easy to implement so we don't have to wait for interstellar travel to get high-resolution images."

He has worked out how massive a body must be to conform to the IAU's orbit-clearing criterion. Above this critical mass, a planet's gravity should be powerful enough to sling away or pull in any smaller bodies within a precisely defined territory called the feeding zone. Given the mass of the parent star and the size of the planet's orbit, you can find the critical mass using a fairly simple formula (arxiv.org/abs/1507.06300).

"I want a classification that applies both to the solar system and to exoplanets, so we don't have to wait"

This formula brings in nearly 4000 new exoplanets, but it has a peculiar consequence. You could define a pair of orbiting objects that both exceed the critical mass as a double planet. A graph created by Margot confirms that the moon is above the critical mass. By this reasoning, it would be a planet too.

"But we should be careful here," he says. "The IAU has not defined the term 'satellite'. When they do, that will affect what they might decide about double planets versus satellites."

The next opportunity for the IAU to reopen the case is at its general assembly in Vienna, Austria, in 2018.

Stephen Battersby ■


NASA

Brave new planet?

NICK UPTON / ALAMY STOCK PHOTO

Eager beavers may help stop floods

Wild beavers are making a splash

Andy Coghlan

SOME 500 years ago they were hunted out of Britain for their fur and meat. Now beavers are making a comeback – at least in small pockets in Scotland and Devon, south-west England – and that may be good news for flood protection and the regeneration of wetlands. But farmers still worry that beaver dams will damage crops and pastures.

New evidence suggests that beaver dams help prevent flooding, cleanse water and boost fish populations and wetland ecosystems. The dams regulate water flow during both heavy rains and droughts. "When it rains, more water gets stored in ponds behind the dams, and when it's drier, water is gently released to keep rivers flowing," says Richard Brazier of the University of Exeter, UK, who has studied half a dozen beavers in Devon.

Four years ago, when two beavers were reintroduced there, the site was a tiny stream flowing through deserted woodland. Within a couple of years, they had transformed it into a rich wetland habitat. "They've built 13 dams and had a profound effect on how the water flows through the site," says Brazier.

Behind the staircase of dams, the beavers built ponds that collectively stored 650,000 litres during heavy rains in November last year – around a quarter the volume of an Olympic swimming pool. This is the kind of measure that some believe would have eased the impact of the 2014 floods in England. If reintroduced on a wider scale, beavers could be of most use in narrow tributaries and headwaters near the sources of major river systems, where holding back water may have most impact on preventing floods further downstream.

Brazier's study also found that the dams filtered out pollutants washed off farms. "On average, each litre coming in contains 150 milligrams of sediment, but only 40 milligrams on the way out," he says. Nitrate and phosphorus levels also dipped dramatically.

The sediments and nutrients that would have tainted downstream water instead fertilised mosses and plants. These attracted insects and frogs, and then large birds. "It's the first time these multiple environmental benefits have been proven," says Brazier.

"Beaver dams have a profound effect on water flow, regulating floods and filtering out pollution"

But beavers don't always do what humans would like them to do. Martin Gayford of Scottish Natural Heritage wrote in a June report to the Scottish government that in areas of intensive agriculture, their dams can block drainage ditches, causing floods that wreck crops. They also started to gnaw through trees beside a busy road and breached anti-flood embankments.

The UK's National Farmers Union is opposed to reintroducing beavers because of such concerns. It says there should be a robust legal framework in place to manage the animals. "If you wanted to manage beavers strategically, it's perfectly feasible if given the time, effort and resources," Brazier says.

Another issue is the perception that beaver dams will damage natural fish populations by obstructing spawning and migration. Scotland earns £70 million a year by attracting enthusiasts of trout and salmon fishing, says Gayford.

But Paul Kemp of the University of Southampton, UK, has discovered that trout may in fact benefit from the presence of deep ponds built by beavers. His preliminary findings compare brown trout from two similar streams that drain into a loch near Inverness, one with reintroduced beavers and one without. "There were more than double the number of trout on the 'beaver stream', and they were bigger," says Kemp. And dams only impeded their movement when river flow was low.

By cleaning the water, beavers make gravel downstream more aerated, which may make it suitable for salmon spawn, he suggests.

So what do these varied impacts mean for the UK's beavers?

The fate of beavers in Scotland – whether to eliminate or manage them, or reintroduce more – is being considered by Aileen McLeod, Scottish environment minister. The UK's Environment Agency is also keeping an eye on new research. "We are particularly interested to see whether the overall benefits of reintroducing beavers outweigh any potential risks," says Alastair Driver, the agency's head of biodiversity. ■

Computer science "result of the decade" found?

NORMALLY a sedate bunch, theoretical computer scientists are humming with excitement after a potential breakthrough in a long-standing problem called graph isomorphism.

The result could provide a deeper understanding of the nature of computing and "might be the theoretical computer science result of the decade", says Scott Aaronson of the Massachusetts Institute of Technology.

"A breakthrough is a big deal – not quite the equivalent of discovering the Higgs boson, but close"

Graph isomorphism concerns whether two graphs – a network of links and nodes – are the same, even if they look different (see graphic, right). The problem crops up in applications like determining the identity of complex molecules. Only the connections between nodes matter, and not their spatial placement, so it can be hard to match one graph to another.

Now László Babai of the University of Chicago, Illinois, speaking in a lecture on 10 November, has announced that this may be easier than thought.

Looking at such questions is the bread and butter of complexity theorists, who seek to classify computational problems by how difficult they are to solve. For example multiplying together two numbers that each have n digits – this calculation requires about n^2 computational steps. All problems with a similar level of difficulty belong to a class complexity theorists call P. In broad terms, problems in this class are easy for computers to solve.

The biggest open question in complexity theory asks how these P problems relate to those in another class, NP. An NP problem is one where if you are given a solution, it's easy to check whether this solution is correct. But for some of the hardest problems in this class – known as NP-complete – finding a solution in the first place can be very difficult. An example is the travelling-salesman problem, which asks if it is possible to find a route shorter than a given length around a group of cities.

We know P is at least a subset of NP, but the mystery is whether these two problem classes might be entirely same. No one has been able to prove this despite decades of research – and the answer is worth $1 million.

So how does graph isomorphism fit in? When the P versus NP issue first reared its head in the 1970s, theorists set about sorting NP problems into P or NP-complete. But graph isomorphism was one of only a few NP problems that couldn't be pinned down to NP-complete or P.

Babai's new result says that solving graph isomorphism takes slightly longer than polynomial time – not quite placing it in P, but significantly shifting the needle for the first time.

People have spent so much time studying the problem with little progress that theorists call it the graph isomorphism disease, says Ryan Williams of Stanford University. A breakthrough is therefore a big deal – not quite the equivalent of particle physicists discovering the Higgs boson, but close. "I'd put it on the level of discovering some new property of a particle that many, many people have studied," he says.

The result doesn't directly address the P versus NP question, but it could provide new ways of attacking it.

"It shows a power of algorithms we didn't know before," says Williams. In probing the boundaries between P, NP and NP-complete, we may find a way to sort between them.

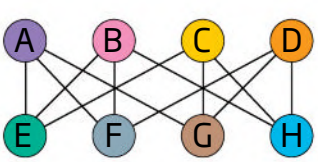
Babai declined to be interviewed about the work, saying it must first stand up to the scrutiny of peer review. "The reaction of colleagues at this point is not celebration but anticipation," he says. "The results need to be verified by the research community."

Reports suggest that Babai's method involves dividing a graph into different parts and solving them separately. Some of these sub-graphs, known as Johnson graphs, are particularly difficult to analyse.

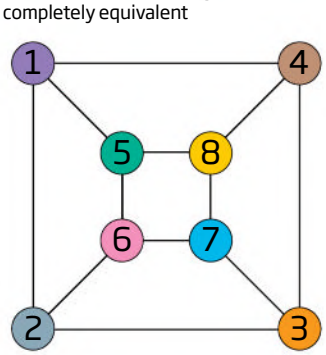
To tackle those, he borrows concepts from important work in another area of mathematics called group theory, known as the classification of finite simple groups. The proof of this is famous in its own right for running to tens of thousands of pages. "It sounds like Babai has built a monster of an algorithm," says Williams. **Jacob Aron** ■

A tangled web

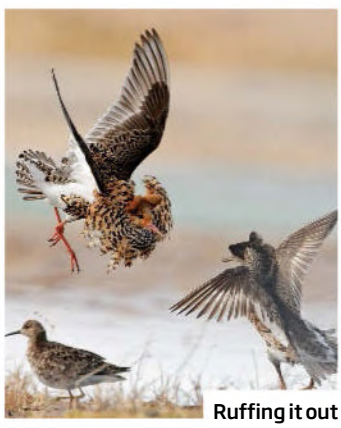
The graph isomorphism problem asks if one graph – the mathematical term for a network of links and nodes – can be rearranged to look like another without cutting any of the links



For example, these two graphs are completely equivalent



Supergene flip allows males to steal matings



SERGEY GORSHKOV/NATUREPL.COM

Ruffing it out

THE ruff has one of the weirdest sexual systems in the world – all thanks to a large piece of chromosome that flipped over 3.8 million years ago.

A type of wading sandpiper, the ruff is named after the showy feathers sported by males around their necks during breeding season. But a rare type of male looks exactly like a female, just bigger. Instead of showing off, it uses sneaky tactics to steal rushed matings. "They seem to operate by complete subterfuge," says Terry Burke at the University of Sheffield, UK.

Now Burke's team, and another one led by Leif Andersson at Uppsala University in Sweden, have independently found that a large chunk of chromosome 11, containing around 100 genes, is upside-down in these female mimics (*Nature Genetics*, doi.org/889; doi.org/89b).

The inversion of this "supergene" region would have protected the genes within it from shuffling between each generation. This allowed a suite of gene variants to evolve together, creating males that look like females but with larger testes than ordinary males. "It's rather like the emergence of a new sex chromosome," says Burke.

Within the supergene, the teams have already found genes involved in processing sex hormones, as well as in colouration, which could explain the plumage differences. Penny Sarchet ■

DAVID WARREN/ALAMY STOCK PHOTO

Can you see me?

Super-recognisers pinpoint strangers

Helen Thomson

CAN you spot a face in the crowd? People with extraordinary recognition skills – or "super-recognisers" – may be particularly suited to jobs in national security.

Identifying familiar faces from CCTV footage is a relatively straightforward task, but identifying unfamiliar ones is much harder. When it comes to border control or a criminal investigation, matching an unfamiliar face from a photograph to a real person can be vitally important.

However, past research suggests that passport officers are no better than other people at matching identities, and few attempts to train people to improve facial recognition have been successful.

An alternative option may be to employ people who have extraordinary face-processing skills. Anna Bobak at Bournemouth University in the UK and her colleagues tested super-recognisers to investigate their value as a resource for national security agencies.

The team showed seven super-recognisers a real CCTV image of a face, and asked them to use this to find the same person in a set of 10 images of similar-looking individuals. Sometimes the right picture was present in this set, and other times it was absent. Super-recognisers correctly identified the person 93 per cent of the time, whereas people with no special recognition abilities were correct 73 per cent of the time (*Applied Cognitive Psychology*, doi.org/87x).

"We found there are super-super-recognisers, and those that are slightly less super than others"

In a second task, participants were shown 20 good-quality images of male and female faces, and then had to complete an unrelated 15-minute task. They were then shown 40 videos of a person walking down a corridor. Half of the videos featured those in the original images. Participants had to say whether each person was one of the initial 20 or not. Super-recognisers were better at this task than the control group, whose success rate was close to that expected by chance.

Bobak says it seems that some super-recognisers are highly skilled at comparing unfamiliar faces, like in the first task, so might be best suited to passport control, for instance. Those who are better at remembering unfamiliar faces for longer periods, as in the second task, are more suited to searching for people in a crowd.

Although super-recognisers scored better in the second task than the control group, only one person really excelled at the test. "When we looked at individual performance, we found significant differences within the group," says Bobak. "There were super-super-recognisers, and those that were slightly less super."

The UK's Metropolitan police force already has about 150 super-recognisers, but only a handful of these are really good, says Josh Davis at Greenwich University, UK, who is involved with the programme. "This research emphasises the importance of making sure you identify the right people for the right jobs." ■

Cancer or not? Let's ask that pigeon

JOB opportunities for pigeons have been few and far between since electronic communication made their skills as messengers obsolete. But now it seems they could be put to work analysing medical images. So says the team who trained pigeons to distinguish between healthy and cancerous breast tissue.

Richard Levenson at the University of California, Davis, and his colleagues showed pigeons microscope images of breast tissue. Then they rewarded them when they correctly pecked a coloured button that corresponded to either cancerous or healthy tissue. After 15 daily sessions, each lasting an hour, the pigeons got the right answer 85 per cent of the time.

Pooling responses from a panel of four pigeons, or "flock-sourcing" as the researchers call it, increased accuracy to 99 per cent. The pigeons were just as good at spotting small calcium deposits associated with cancer, which appear as white specks on mammograms (*PLoS One*, DOI: 10.1371/journal.pone.0141357).

Pigeons' visual skills are well studied: they can recognise human faces, letters of the alphabet and even distinguish paintings by Monet and Picasso.

While doctors won't be turning to pigeons for a cancer diagnosis any time soon, the birds could play a useful role in the development of image analysis technology. Researchers develop software that manipulates medical images so doctors can interpret them more easily, but it takes several hours to work out if the software helps or hinders a diagnosis.

Here's where the pigeons come in, says Levenson. He says that pigeons' sensitivity to features in medical images that are important for diagnoses make them ideal for providing feedback on several aspects of their software development. "They can assist researchers as they innovate," he says. Sam Wong ■

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Alzheimer's arrived by conquistador

Rowan Hooper

THE town of Yarumal in Colombia is famous for all the wrong reasons: it has the world's largest population of people with Alzheimer's disease.

In Yarumal and the surrounding state of Antioquia 5000 people carry a mutation which causes early-onset Alzheimer's – half of them will be diagnosed by age 45, and the other half will succumb by the time they are 65.

Locals call it La Bobera – "the foolishness". Now researchers have traced the ancestry of the mutation, concluding that it was probably introduced by a Spanish conquistador early in the 17th century.

Ken Kosik at the University of California, Santa Barbara, and colleagues collected blood samples from 102 people in Antioquia and sequenced their genomes. The mutation causing this form of early-onset Alzheimer's is found in a gene on chromosome 14 and is called E280A – 74 people had the mutation.

Because Kosik's team had information on the genome sequence around the mutation, they could use something called identity-by-descent analysis to determine how the people in the study were related. The analysis suggested the mutation arose from a common ancestor around 375 years ago.

The geneticists then compared the genetic profile of an Antioquian carrier of E280A against genetic profiles from three potential continents of origin, and the evidence pointed to Western Europe (*Alzheimer's and Dementia*, doi.org/f2vs4s).

This is consistent with a Spanish origin for the 17th-century carrier of the initial mutation, the team say. The conquistadors – soldiers and explorers of the Spanish Empire – began colonising Colombia in the early 16th century, and Yarumal itself was founded in 1787.

"It's hard to explain why all these people would share such a large chunk of DNA if there hadn't been a common founder," says Kosik.

"Putting the genetic data and the historical records together, the assumption that the mutation was introduced by one Spanish conquistador is very likely," says Rita Guerreiro, a geneticist at University College London.

One reason that 99 per cent of Alzheimer's drug trials fail is because the drugs are tested after the disease has taken hold. Yarumal is one of few places in the world where researchers can be sure a sizable proportion of people will develop Alzheimer's, giving an ethical reason to test new drugs on people before they show symptoms.

The people recruited for genome sequencing in Antioquia were not told whether they carry the E280A mutation. "We made a decision, with a great deal of agony, that we wouldn't tell them as there are no genetic counsellors over there," says Kosik. Counselling is vital, he says. "There was a 24-year-old kid who said he'd want to know the outcome of his test. 'But there's no treatment,' we said. The boy put his hand in the shape of a gun to his head."

James Pickett, head of research at the Alzheimer's Society, UK, was encouraged by Kosik's discovery. "There's been a lack of clinical trials looking at inherited Alzheimer's disease, so new research that helps us to understand the origins of a genetic mutation across generations is interesting," he says. ■

DAVID WARREN/ALAMY STOCK PHOTO

The Antioquia "foolishness"

Anti-booze drug gives hope for HIV cure

THIS could be what HIV researchers have been waiting for – a way to flush the virus out from its hiding places. The surprising culprit is an anti-alcohol drug that's been used for decades.

Known as Antabuse or disulfiram, the drug is given to alcoholics so that they will vomit if they drink. But now a small clinical trial suggests that disulfiram may also wake up dormant HIV in infected people. If bigger trials support the finding, the drug could be a vital step towards a cure.

Today's antiretroviral drugs can eradicate HIV from the blood, but the virus can hide in a dormant state elsewhere in the body. To prevent the virus re-emerging, people with HIV have to stay on these drugs for the rest of their lives.

But if we could somehow wake up the dormant virus and flush it from its hiding places, it might be possible to kill it off once and for all. To do this, we need drugs that can prod the virus into life, but until now the main candidates have had too many toxic side effects to be a realistic option.

"Disulfiram is very safe and can easily be given for weeks or months," says Sharon Lewin of the University of Melbourne, Australia, whose team has tested the drug on 30 people with HIV over a period of three days.

Over that time, they found an increase in HIV gene expression in all the volunteers (*The Lancet HIV*, doi.org/893). The researchers think this is a sign that dormant virus had been woken up, although they can't be sure without further tests.

"This drug can't do it alone, but it could be combined with others to perhaps completely kill off HIV"

Disulfiram alone won't do the trick, but it is a promising candidate for combining with other drugs, says Asier Sáez-Cirión of the Pasteur Institute in Paris.

Now the search is on to find a second drug that can finish off the re-awakened virus. Existing antiretrovirals wouldn't work because they do not kill infected cells, they only prevent the virus from infecting new ones. Andy Coghlan ■

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AGE FOTOSTOCK/ALAMY

Crumbling Greenland glaciers to raise sea levels by 1 metre

THE rot is spreading. Yet another of the immense glaciers that drain the vast Greenland ice sheet has begun to retreat. It could eventually contribute half a metre to sea level rise.

Some of Greenland's glaciers rest in deep fjords, and as the water warms, their leading edges melt. The ice within them is also moving towards the sea faster – so more is being dumped in the sea. The process began with the vast Jakobshavn glacier in the west, followed by the Petermann and Humboldt in the north.

Last week, it was announced that the Zachariæ Isstrøm glacier in the north-east began to retreat in 2012 and its flow towards the sea also accelerated (*Science*, doi.org/87z). "Now it's unstable and it's going to retreat even more," says team member Jeremie Mouginot of the University of California, Irvine, whose study was based on data provided by six space agencies.

The next glacier to the north, Nioghalvfjerdsfjorden, could follow suit. The floating ice shelf that protects it is thinning and could soon be lost. Most of the ice shelves in the seas around Greenland have already disappeared.

The melt will add millimetres to sea levels over the coming decades, says Mouginot. Over the coming centuries, though, enough ice could flow out through Zachariæ Isstrøm and Nioghalvfjerdsfjorden alone to raise the sea level by 1.1 metres.

England's antibiotics hotspots named

FRESH air and antibiotics. Living by the sea is anything but healthy, judging by the first ever maps of where family doctors in England prescribe the most antibiotics.

The maps reveal prescription hotspots on the coastlines of Norfolk and Lincolnshire, and in towns along the south coast. The highest rate, averaging more than one prescription per person in 2015, was in Clacton-on-Sea, Essex.

Based on 600 million prescriptions given out over a period of five years, the maps are intended to help crack down on antibiotic resistance. "The more antibiotics are used, the more likely it is that resistance will develop," says Colin Garner of charity Antibiotic Research UK, which commissioned the maps.

Many hotspots are known areas of deprivation. "We know poorer people have worse diets and are less healthy than rich people, so they are more likely to go to the doctor," says Garner.

But richer areas aren't immune to high levels of prescribing, and in some cases a map is so detailed that it's possible to single out one particular surgery. A hotspot in London's Chelsea area turned out to be down to one GP visited by Chelsea pensioners – war veterans in nearby charitable housing.

Earth's water older than planet itself

HOW did Earth get its water? It seems it had it all along.

There are two possible sources for our water: bombardment by meteorites soon after Earth's formation, or it was present in the dust that our planet formed from.

So a team led by Lydia Hallis, now at the University of Glasgow, UK, looked at the ratio of heavy hydrogen, known as deuterium, and normal hydrogen in water trapped for 4.5 billion years in volcanic basalt rocks on Baffin Island in the Canadian Arctic.

They found little deuterium, which rules out meteorites, since they normally have more of this isotope, Hallis says. Instead, the water must have originated in the dust cloud from which our solar system originally condensed (*Science*, doi.org/875).

If so, that raises the likelihood that water – one of the key prerequisites for life as we know it – is native to other planets.

Powder glue sticks when squished

DRIED-UP glue may come in useful. A powdered form of adhesive could help stick things to rough or inaccessible surfaces.

Most glues are either liquids that dry, or solids that become viscous and sticky when heated . Now Syuji Fujii of Osaka Institute of Technology in Japan and his team have made a powder that becomes a glue when squished.

The powder is made up of "liquid marbles" – beads of latex liquid coated in solid particles that trap the fluid inside. A few seconds of pressure pushes the solid particles inside, exposing the sticky liquid to the surface (*Materials Horizons*, doi.org/877). It out-sticks the glue on Post-it notes and tape, and can adhere to rough surfaces like wood, Fujii says.

Ant that does the work of a door

WHEN the head's not a rocking, don't come knocking. Ants from several genera have evolved flattened heads that look and act like a door, deterring uninvited guests.

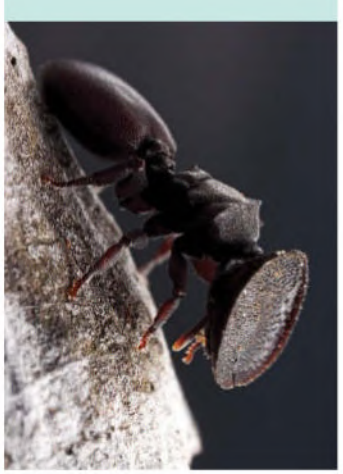
Now a team led by Georg Fischer at the Okinawa Institute of Science and Technology in Japan has described two new species of genus *Carebara* found in Kenya and Ivory Coast (*ZooKeys*, doi.org/872).

Little is known about them, but they look much like the better-studied door head ants of genus *Cephalotes* from the Americas. Shaped like shields, their heads are a perfect fit for the tunnels created by wood-boring beetles in trees.

"If you live in a tight tunnel like that, if anything invades the space you're basically trapped," says Steve Yanoviak of the University of Louisville. "It's a non-aggressive, non-violent way of protecting yourself."

Often, the ants' heads are camouflaged, either by a secretion of tangled fibres that look like fungi, or by forest debris caught by small hairs that act like Velcro. Once an unwanted visitor is seen they lock themselves into a defensive position, blocking the tunnel entrances and making their nests harder to spot.

"It's like wow, that's really cool – there was a hole there and now there's not. It's pretty amazing how their heads resemble the surrounding bark," Yanoviak says.



ALEX WILD

We're still feeling the glow of a 2-million-year-old supernova

ALL signs point to a supernova. A stellar explosion 2 million years ago that flooded our neighbourhood with charged particles could be the answer to several cosmic puzzles.

For years, astrophysicists have struggled to explain why there are so many high-energy cosmic rays – speeding charged particles – hitting Earth. We'd expect most to have collided with other particles long before reaching us.

A supernova could act as a local cosmic particle accelerator, but previous models haven't been able to fully account for the number of cosmic rays.

That might be because the distribution of cosmic rays is uneven throughout the galaxy, says Dmitri Semikoz at the Astroparticle and Cosmology Laboratory in Paris. It's like watching a firework display and assuming that the sky looks bright and colourful everywhere, instead of looking to see if someone recently set off fireworks nearby.

Semikoz and his colleagues modelled a nearby supernova and predicted the cosmic ray energies we should later see on Earth. Then they checked these against data from several current experiments.

The best fit was a single supernova exploding between 2 and 4 million years ago.

And we already know of a supernova that fits this description. Parts of the deep ocean crust contain an isotope of iron that is thought to be the fingerprint of a 2-million-year-old supernova. The team suggests that this supernova could be the source of the cosmic rays (*Physical Review Letters*, doi.org/878).

Exoplanet baby photos snapped

AWW, who's a widdle planet, then? Astronomers have got their first glimpse at baby worlds growing around a distant star. Watching them develop into strapping Jupiters should give us a better understanding of how planetary systems form.

We've found nearly 2000 exoplanets, but so far planetary formation has only been seen indirectly. Now Stephanie Sallum of the University of Arizona, Tucson, and her colleagues have spotted direct signs of a young trio of protoplanets bulking up.

The team studied a star called LkCa 15, which is only 2 million years old – a cosmic blink of an eye. It is surrounded by a doughnut-shaped dust and gas disc, and observations in 2009 suggested three newborn planets about the mass of Jupiter are forming in the central hole.

The team confirmed the existence of those planets, then observed one wavelength of light, called H-alpha, given off by glowing hydrogen gas, which showed they were growing. The signal from the innermost planet, LkCa 15 b, suggests that hot gas is falling on to it as it grows (*Nature*, DOI: 10.1038/nature15761).

LAURA BEACH/PLAINPICTURE

What's yours is mine, or none at all

KIDS are notoriously bad at sharing, but their sense of fairness may be culturally determined. Children from Western cultures are more likely to reject an offer that unfairly benefits them than kids from other countries.

To study when a sense of fairness develops, Peter Blake at Boston University, Katherine McAuliffe at Yale University and their colleagues played an inequality game with 866 pairs of children from Canada, India, Mexico, Peru, Senegal, Uganda and the US. In each game two kids were allocated different numbers of treats, with one deciding whether to accept the amount on behalf of both.

Children from all cultures turned down receiving less than their partner, between the ages of 4 and 10, suggesting this form of fairness is universal, says Blake. However, only older children from the US, Canada and Uganda rejected an allocation that favoured them over the other child – starting at around age 11 (*Nature*, DOI: 10.1038/nature15703). "This behaviour seems shaped by culture," says Blake. Further work suggested Western teachers might have an influence on how these childrens' ideas developed.

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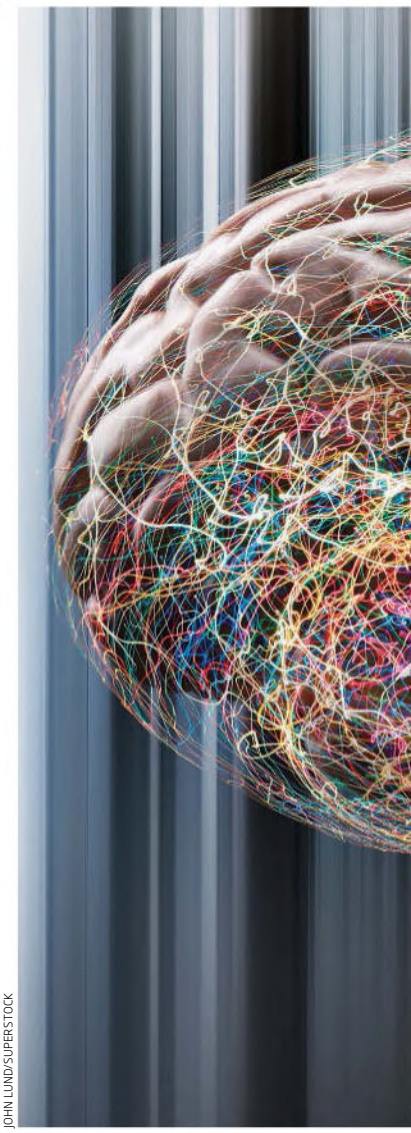
Mind adapts to machine

New ways of connecting our brains to computers can change the way we use both of them. **Aviva Rutkin** plugs in



JOHN LUND/SUPERSTOCK

GRADUATE student Sam Hincks sticks a wet electrode to my forehead, then another, tucking them in place under a black Tufts University sweatband.

"Are you nervous?" he asks.

I am, but I don't want to lose my cool. "A little," I say.

Hincks flips the switch. It takes a moment, then I feel a slight, sharp tingle, crashing in waves somewhere just out of my line of sight. One milliamp of current is flowing between the electrodes – through my brain.

The little zap is called transcranial direct current stimulation (tDCS) and I am in Robert Jacob's lab, up on the fourth floor of a Tufts University research building in Medford, Massachusetts. The researchers are exploring the possibilities for computers and wearable devices to read what's going on in the brain and stimulate it in specific ways.

Jacob's lab is dedicated to improving the relationship between humans and machines, finding a way for one to communicate more easily with the other. He imagines the fluctuating stress and thoughts of the brain as a dial: if you want to let a computer know how you are feeling, you could manually turn a knob up or down, or you could find a way for the computer to tune into those changing states automatically. Perhaps the computer might even start turning the dial itself.

"Our goal is to improve the bandwidth between two powerful processors: the human and the computer"

"I think of the human and the computer as two powerful information processors connected by a narrow channel," says Jacob. "Our goal is to improve the bandwidth between the two."

To get information out of the brain, Jacob's lab relies on a technique called functional near infrared spectroscopy (fNIRS). Tack two sensors onto the forehead and shine harmless red light through a few centimetres of skull and skin. The light is absorbed and scattered by blood in vessels at the brain's surface. The amount that bounces back to the sensors is a proxy for the oxygen levels in the brain. High oxygen means high activity, a sign that you're thinking hard.

The team has already used this system to enable a computer to track and adjust to a person's cognitive state. One recent device sends the oxygen levels to a Google Glass. If it judges the user's brain to be busy, it holds off sending any notifications until activity levels die down. Another system follows the progress of novice piano players as they plunk their way through a new piece. It ramps up the difficulty of the song when the players' workload dips below a certain threshold, indicating they've mastered a section.

Such systems mean the world can start adapting to the brain's ability to cope with it. When someone tries one of these devices for the first time, a machine-learning algorithm steps in to calibrate the sensors for their brain. This takes a while, and is one of the barriers to consumer adoption. When I try fNIRS, I spend 5 minutes doing simple mental arithmetic while Hincks gets calibrating. By the end, he says the computer has learned enough to predict my cognitive workload with 75 per cent accuracy.

The device can tell if a person is working hard or cruising. But as computers move onto our foreheads and arms (see "Arm hacking", right), what if they took the next step, giving us a little zap when we seem to be struggling? That's where tDCS comes in. Jacob wants to use it to tune the brain for the task at hand.

It is simple and cheap to set up: aspiring biohackers could make their own tDCS devices for about $20 using instructions off the internet. Just place spongy electrodes, wet with salt water, on the head, then run current from a 9-volt battery through them. The idea is that the electricity will change the excitability of some neurons, making them more or less likely to fire. The technique has already been studied as a treatment for depression, strokes, and even tinnitus. Jacob's lab wants to use it to interact with our devices.

His team's first goal is to understand how different people

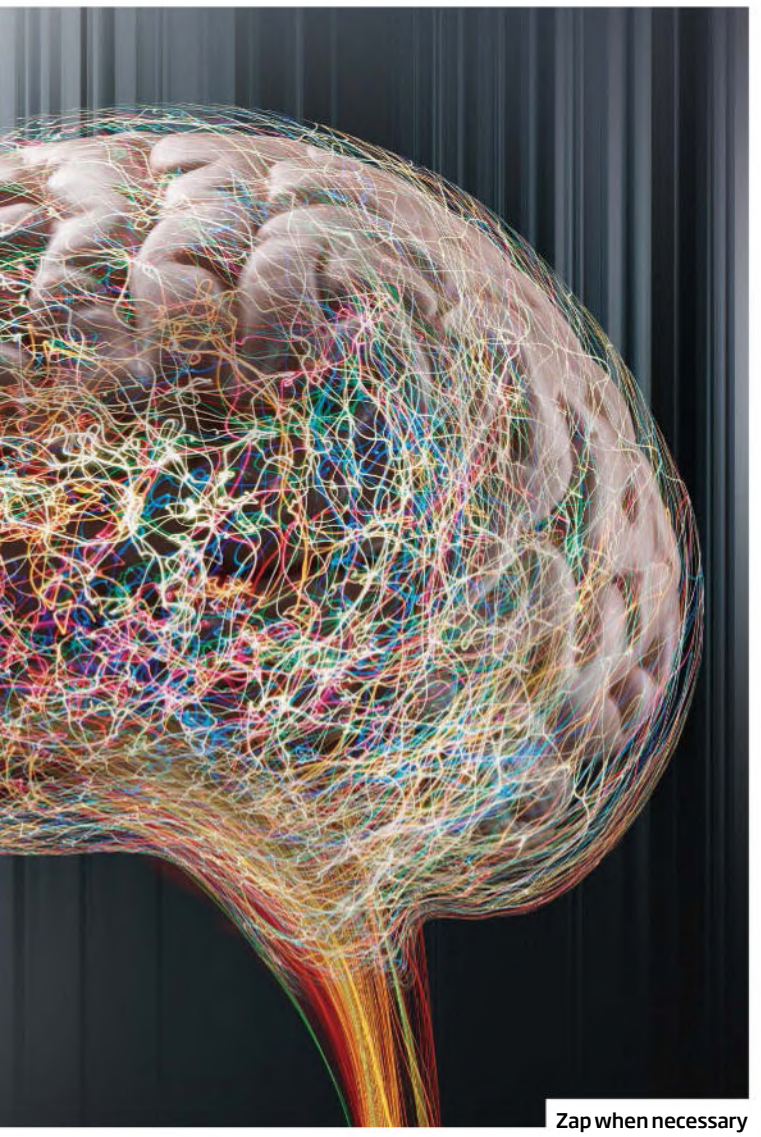
ARM HACKING

What are you doing now? Your next wristwatch may know the answer. While some researchers focus on computer-to-brain connections, a lab at Carnegie Mellon University in Pittsburgh wants tap into muscles.

Its smartwatch prototype, Tomo, tracks the wearer's hand gestures in real time, relying on an imaging technique called electrical impedance tomography to see inside the arm.

The watch band is studded with copper electrodes that can bounce electrical signals between them to build a picture of muscle activity in the wrist.

In a demonstration at the User Interface Software and Technology in Charlotte, North Carolina, last week, the researchers hooked Tomo up to a Samsung Galaxy smartwatch. This allowed the wearer to flip through new messages with a flick of the hand to the right or left, and answer phone calls by making a fist.



Zap when necessary

respond to tDCS. "We think that people who have more of a response as measured by fNIRS would be more helped by stimulation," says Hincks.

After that, the first test for tDCS might involve flying virtual drones. Jacob's lab works with a simulation which puts the player in control of a number of imaginary UAVs, each of which needs to be steered around obstacles to its target. In early tests, players were fitted with the fNIRS sensors, and the computer added or removed drones from their control according to their cognitive workload.

With tDCS, the computer could give the user a zap when it senses a dip in their abilities, adapting the user's brain to their task, rather than the other way round.

"We want to just crank it up for a minute or two and then crank it down. We're looking for this very fine-grained control," Jacob says. "We're looking to measure you with fNIRS and, based on what we measure, slowly tweak this. It's a sort of two-way communication with the brain."

"The computer adds or removes drones from the player's control according to cognitive workload"

Roi Kadosh, a cognitive neuroscientist at the University of Oxford, cautions that tDCS may not offer a boost to everyone. In a study published last December, he and his colleagues stimulated the brains of people who had high levels of anxiety about mathematics. For them, the stimulation seemed beneficial: their reaction times on simple arithmetical problems improved and they had less cortisol in their saliva, a sign of lower stress. But when a group with low anxiety about mathematics tried to solve the same kinds of problems after tDCS, their performance actually got worse. Similarly, he says, other groups of people may not get an edge from tDCS.

Baby aspirin stage

"Those with high cognitive abilities might not benefit from stimulation. They might even show impairments," Kadosh says.

And not everyone is convinced of the current's power. Jared Horvath and colleagues at the University of Melbourne in Australia have reviewed the results of hundreds of studies involving tDCS, and found that its reported benefits – increased speed when completing tasks, higher accuracy, better memory – were inconsistent.

Marom Bikson, a biomedical engineer at the City College of New York, who studies electricity's effect on the body, says there are some essential questions scientists must answer before tDCS becomes widespread: what brain region should be stimulated and at what strength; and is stimulation better before, during or after an activity?

"We're in the 'baby aspirin' stages of tDCS," says Bikson. "We have a tremendous amount to learn about how to optimise it."

So tDCS won't be out in the real world just yet. But if it can get there, it may usher in an era where not only do our devices adapt to us, we adapt to them. ■

ONE PER CENT

Go on, smile...

Every face tells a story. Researchers at the University of California, Berkeley, analysed more than 37,000 high school yearbook photos to see how faces changed over time. They found that students' smiles have grown wider for the past century. The average photo in 1900 and 1910 shows a neutral expression. By the 2010, the average face is lit up with a broad grin (arxiv.org/abs/1511.02575).

"Driving too slowly? Bet humans don't get pulled over for that too often"

Google's statement after one of its driverless cars was pulled over for travelling too slowly.

Electric feels

Chalk up another win for computers. Software developed at the University of Rochester in New York is better at identifying emotion in speech than we are. When analysing 700 audio samples, the system got the emotional sense right 72 per cent of the time. A group of 138 humans averaged just 60 per cent accuracy on the same clips. The team plans to use it to study emotion in parent-child interactions (arxiv.org/abs/1510.06769).

KAREN KASMAUSKI/CORBIS


UNIVERSITY OF COLUMBO

Too close for comfort?

Infrasound radar listens for elephants' rumbles

IN JANUARY an elephant entered Moragoda village in northern Sri Lanka and killed a father in his vegetable garden. In July, a dairy farmer from the east was killed taking his cow out to graze. Now an ambitious project aims to warn communities when elephants approach by tracking these giants around the country via their rumbling calls.

Chamath Keppitiyagama of the University of Colombo is working on a radar system that listens out for the inaudible rumbles of elephants' infrasound, something that was discovered in the 1980s. Infrasound is useful for locating and tracking elephants over long distances – the low frequency means the sounds travel a long way through the air.

By understanding how elephants move around, communities should be better prepared for encounters, which are becoming more frequent as Sri Lanka's population of both humans and elephants grow. The human population has doubled since the 1960s to more than 20 million. At the same time, the country's long-term decline in elephant numbers has reversed. Falling from 12,000 at the turn of the 20th century to 2000 by 1990, elephants have now rebounded to almost 6000. That brings the two groups into conflict. Roughly 70 people die every year, with 250 elephants shot, poisoned or electrocuted in turn.

The researchers are building software to help their sensors pick infrasound out of the background noise. This means recording a lot of elephant grunts. In July, the team travelled to western Sri Lanka to record celebrity elephant Nadungamuwa Raja, one of just a few elephants with a Wikipedia page.

"Infrasound could help people guard their crops if they knew that elephants were nearby"

Wouldn't it make more sense to track elephants with GPS? Keppitiyagama says it has been tried. But making a tracking collar that can stand up to the elephant lifestyle is tough. "Elephants go and dip in lakes, rub their heads on trees and get into muddy ponds, all sorts of things, so this device has to be really rugged, and that means expensive," he says.

Eva Gross of French NGO Awely, which works on solving conflict between animals and humans, says the infrasound radar is promising, especially in heavily populated countries like Sri Lanka. "I could imagine very well that it could help in areas where you have a dense human population, and people need to be warned whether they can pass through an area by foot or not," she says. It could also help people guard their crops from elephants, if they knew that they were nearby.

In tests, the existing setup can identify recorded infrasound from 300 metres away. And real elephants are about eight times louder than the infrasound player. "We expect to detect elephants over a few kilometres at least," says Keppitiyagama.

Villagers would have enough time to grab tools to fend off the elephants. Gross advocates chilli. "Elephants don't like the smell of chilli smoke," she says. "Burning chilli on elephant dung to produce a lot of smoke is a good approach." Keppitiyagama's team are working on a chilli gas dispenser that consists of a ping-pong ball filled with chilli oil that can be fired at the elephant. **Hal Hodson** ■

Ear sensors can "hear" your silent speech

READ my lips. An invention can recognise "silent speech" by keeping tabs on your tongue and ears.

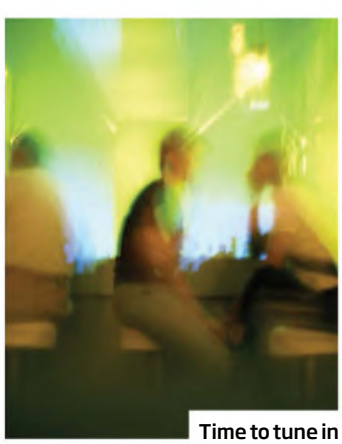
By training it to recognise useful phrases, it could allow people who are disabled or work in loud environments to quietly control devices.

A team including Thad Starner at Georgia Institute of Technology, Atlanta, has created a device that combines a magnetic tongue-control system – already used to help people who are paralysed drive a wheelchair – with earpieces that look like headphones.

Each earpiece has a sensor that uses infrared light to map the changing shape of the ear canal. Different words require different jaw movements, deforming the canal in slightly varying ways.

As a test, the team listed 12 phrases that might be required, such as "I need to use the bathroom" or "Give me my medicine, please". People were then recorded repeating these while wearing the device.

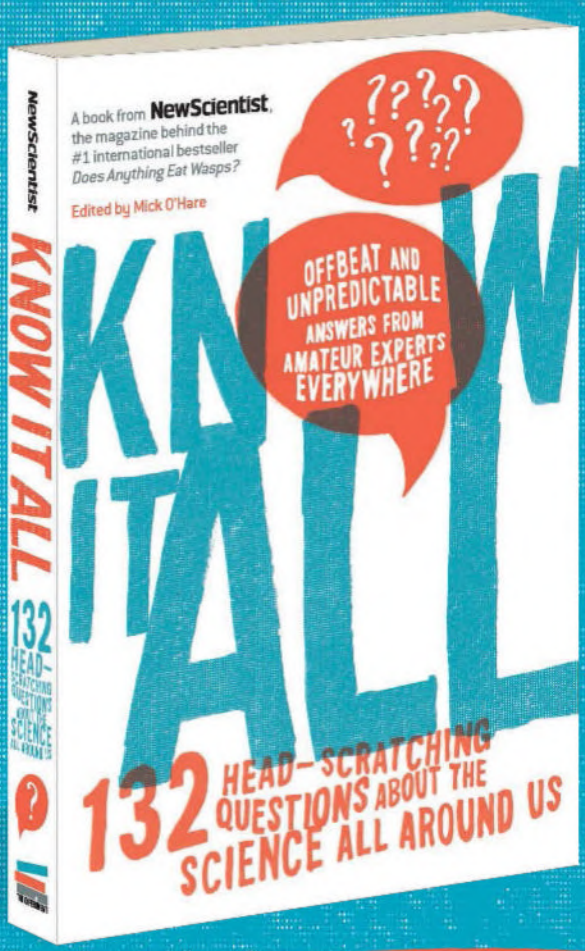
With both the tongue and ear trackers in, the software recognised what the wearer was saying 90 per cent of the time. Using ear trackers alone, the accuracy was slightly lower (*Computer*, doi.org/887). The team will create a phrase book of sentences that are recognisable from the ear data.
Aviva Rutkin ■


RYAN MCVAY/GETTY

Time to tune in

THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . .

KNOW IT ALL



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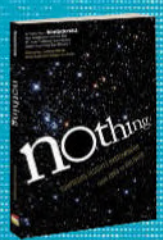

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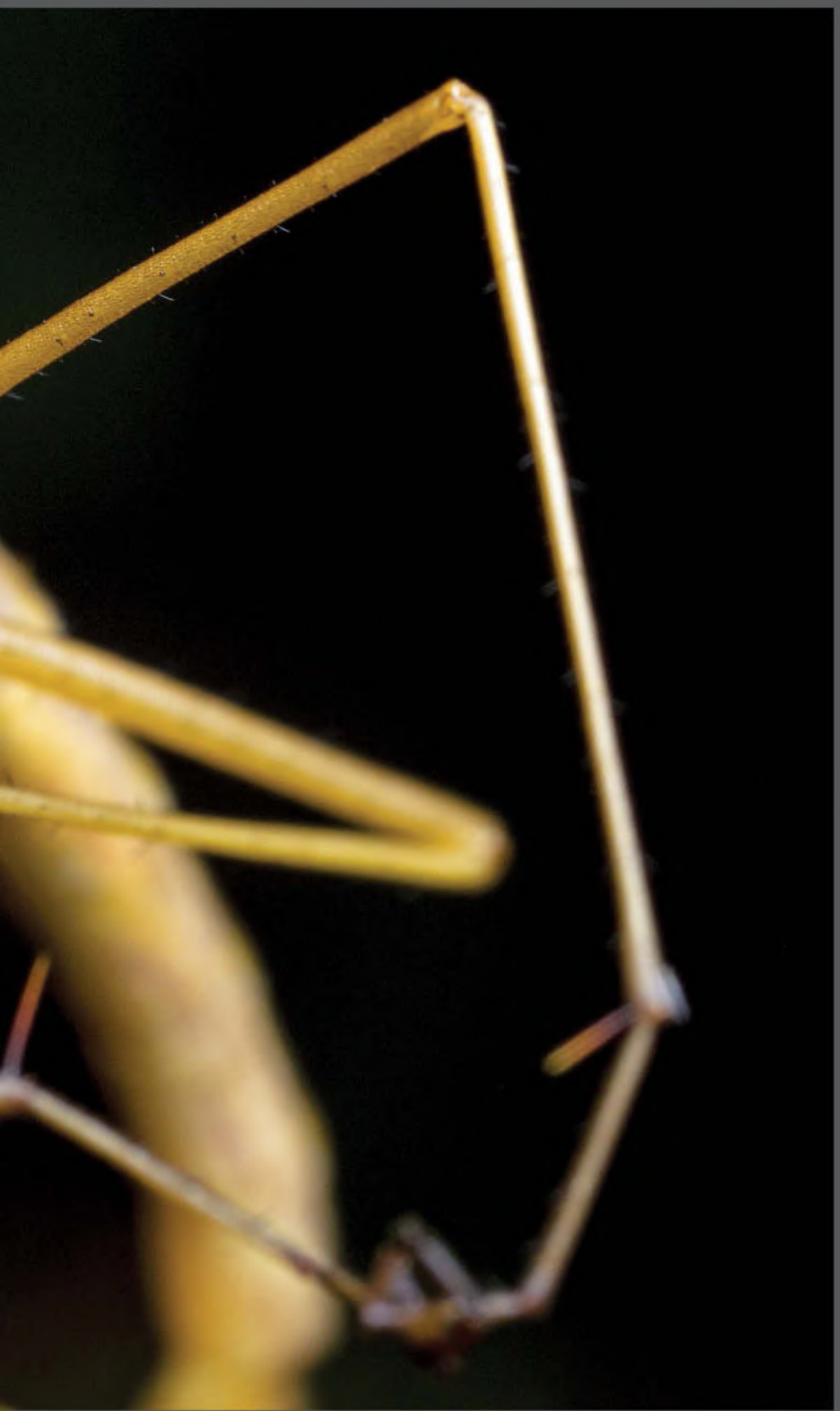


Lovers share a meal

IF YOUR first instinct is to react with revulsion at the sight of these two insects, please hold on for a moment. Because this photo captures something that goes to the heart of what it means to be a motile life form – at least, for those that reproduce sexually.

These animals are wingless scorpionflies, *Apterobittacus apterus*. "Aptero" means wingless – this insect is so wingless they had to tell you twice. While it looks like the animals are sharing a meal in this photo, something more interesting is going on. The food in question is a dead insect, probably a planthopper. Not very appetising to us, but to female wingless scorpionflies it is what entomologists quaintly call a "nuptial gift". In other words, it is what the male gives the female to secure copulation.

When Alex Wild took this photo, at the University of California's Hastings Natural History Reservation in Carmel Valley, the insects were already copulating. We don't know much about this species, but in related species male reproductive success is correlated to the size of the prey he offers. "Even though this pair did mate," says Wild, "I can't imagine the female was that impressed by the, um, small size of this male's package." Rowan Hooper

Photographer
Alex Wild
alexanderwild.com

Up in flames

Pledges to curb carbon emissions in parts of Africa could falter given the hurdles ahead. Just look at Malawi, says **Roger Harrabin**

MOST electricity in poverty-stricken Malawi comes from renewable sources. Solar panels on some school roofs are a prime example. They have improved students' results as well as providing income by charging villagers' phones and batteries for a fee. What little central generation takes place in this corner of Africa is mainly hydropower.

This all sounds relatively green, until you realise the country has one of the highest deforestation rates in the world. Trees are often felled to provide fuel for cooking. Fewer trees means less ability to absorb carbon dioxide and it exposes soil, which means it also releases CO_2. This is Malawi's biggest contribution to climate change by far.

Denuded land means rain runs off rapidly. Aquifers don't get replenished; instead rivers swell and burst their banks. The run-off takes with it silt and debris that can block the intakes of hydropower plants, adding to supply problems already caused by erratic rains. Black-outs are common for the small proportion of Malawi's 17 million people and businesses connected to the grid.

So what is the country's answer? Plans for two coal-fired power stations, which will ensure a more constant supply to an increased number of people and businesses.

The government realises that this will raise carbon emissions, but it says Malawi needs this kind of low-cost, reliable power supply for development.

So while energy sector emissions would rise, it aims to do its bit by addressing the worse problem of deforestation. This is the basis of its pledge ahead of the UN's Paris climate summit.

Part of that pledge is to have

Feeling sidelined

Africa is on the climate-change front line yet its voice is not fully heard, says **Curtis Abraham**

A 2 °C rise in global temperature could have a profound impact on Africa. GDP could reportedly dip 4.7 per cent, mainly through agricultural losses.

The continent would face other environmental degradations. Temperature rises are predicted to be more pronounced there than the global average and are already having an impact on things such as water availability and power generation. A lack of rain recently saw all hydropower plants in Tanzania switched off.

Yet rich nations – removed from such impacts – largely set the climate-change agenda. The developing world is crying foul, feeling left out of the debate.

International journals dominate on climate papers. Although research collaborations between Africa and richer regions do exist, few African climate scientists are published in big peer-reviewed journals and other important publications.

This is partly down to the region prioritising practical, everyday problems above journal publication. For example, the Energy Research Centre at the University of Cape Town is South Africa's leading institution for research on climate change, but it focuses on joint projects between the state, academics, industry and NGOs. As a result, policy briefs dominate, not journal articles. Financial and resource constraints also hamper publication.

"A deficit of African knowledge in Western journals could hamper climate policies"

The result is a deficit of African knowledge in the big journals, which could further hamper the development of climate policies.

Discontent is real. During a recent meeting in Arusha, Tanzania, African climate negotiators threatened to block any potential agreement on reducing global warming if it's not kept to 2 °C or less. They also want

2 million more efficient stoves in operation by 2030, each estimated to use less than half as much wood as a traditional open fire. As part of the Paris deal, Malawi is asking for international help to promote these stoves and to increase tree planting.

It all sounds encouraging. But unless there's a miraculous turnaround, the birth rate of more than five children per woman, which could mean 40 million citizens by 2040, will undermine gains from more efficient stoves.

Observers have concluded that drivers of climate change cannot be easily tackled in such countries where largely rural populations are forced to degrade the land to meet their needs.

The best solution, they say, is to create densely packed cities with public transport, powered by renewables – Malawi has excellent potential for solar power. Experts in Malawi say the government, beset by corruption scandals, is in no state to fulfil that mission.

It's nice to think that there are simple fixes to global warming. The reality, as Malawi illustrates, is a lot more complex. ■

Roger Harrabin is the BBC's environment analyst. He presents *Changing Climate* on Radio 4 at 8 pm on 23 November

funding to meet the estimated $10-20 billion a year needed to adapt to climate change, as well as green-tech support and better recognition of indigenous environmental know-how.

Better funding for research in Africa, better-stocked scientific libraries, faster computing and action on high fees charged by some journals would help.

We need to expand knowledge about climate change to include all the world's best minds – not just those in traditionally favoured locations. ■

Curtis Abraham is a writer based in East Africa

ONE MINUTE INTERVIEW

Welcome to biscuit land

My Tourette's makes it impossible to stay on script, but I embrace this spontaneous creativity, says **Jess Thom**

COURTESY OF JESS THOM

PROFILE

Jess Thom runs Touretteshero, an organisation that celebrates the creativity of the syndrome's uncontrollable verbal tics. She is the creator of *Backstage in Biscuit Land*, a stage show about her experiences, soon to go on tour in the UK.

How does your Tourette's manifest itself?
Hedgehog. Biscuit. Well, ***biscuit***, like everybody with Tourette's, ***biscuit***, I have multiple motor tics, and at least one vocal tic. ***Biscuit. Hedgehog. Biscuit.*** Anything that I've ever known or experienced has the potential to become a tic. ***Biscuit.*** So very unusual ideas, ***biscuit***, often get thrown together by my neurology and they create unusual new concepts. ***Biscuit. Hedgehog. Cats.***

Would you mind if we replicated your last answer verbatim, tics and all?
I'm happy to do that, yes.

Do your vocal tics ever surprise you?
The biggest misconception people have about Tourette's is that it's the "swearing disease". In fact, only 10 per cent of people with Tourette's have obscene tics. I am one of that 10 per cent, but even so I rarely swear. I say "biscuit", "hedgehog" and "I love cats" a lot at the moment. I actually don't have any strong feelings about cats, but now I profess my love for them every few minutes. My vocal tics do often surprise or shock me. Not because they're rude, but because they can be funny or surreal.

How did you learn to embrace that creativity?
A friend once described my Tourette's as a "crazy language-generating machine" and encouraged me to do something creative with it. That led to the foundation of Touretteshero, an organisation centred on my superhero persona. It's about recognising that Tourette's gives me the power to access a spontaneous creativity that other people perhaps can't do in the same way. As an organisation we use humour and creativity to get people to think about and celebrate differences.

What can thinking differently about Tourette's achieve?
We're used to considering only negative connotations but there is an incredible disability culture thriving in lots of areas of life including arts and sports. But Touretteshero isn't just about encouraging people with Tourette's or getting people to think differently about it. It's about getting everybody to engage with the condition and to use tics as a creative catalyst: whether that's for new artwork and music, or for research partnerships and scientific exploration.

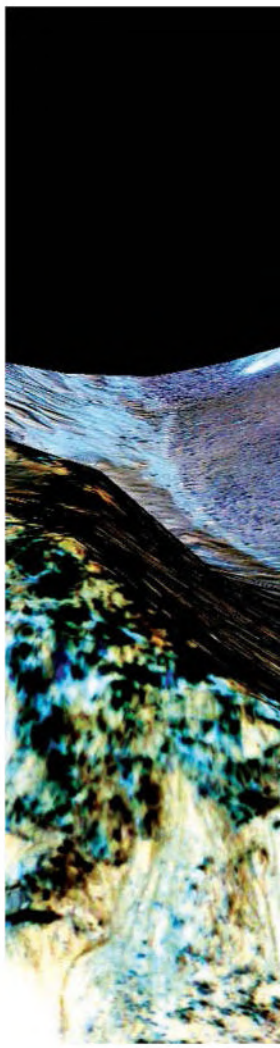
What motivated the stage show that you're involved with, *Backstage in Biscuit Land*?
This had its roots in some difficult experiences I've had at theatres and live performances. I was once asked to move to a sound booth when other people threatened to leave because of the noise I was making. That was incredibly humiliating but it eventually motivated me to look for the one seat in the house I wouldn't be asked to leave.

Creating the show was an interesting challenge, because I'm neurologically incapable of staying on script. So it doesn't matter how much I want to try to say or do something in exactly the same way each time, Tourette's means that I'm never going to achieve that. But I think it makes for a more interesting show.

Interview by Gilead Amit

Alien life – not necessarily as we know it

If we find life elsewhere in the cosmos, we shouldn't be surprised if its building blocks are fundamentally different from ours, says **Steven Benner**



Watery Mars: life there might exist without proteins

PROFILE
Steven Benner is one of the founders of the field of synthetic biology. He is at the Foundation for Applied Molecular Evolution in Florida

WE TAKE for granted much of what we see in the world around us. We don't often think about the fact that we have 10 digits on our hands, for example, unless jolted by observing a different life form – *The Simpsons* perhaps, with their eight digits.

For us, our finger number reflects choices made millions of years ago. This number could have been determined simply by accident. Once determined, it may have been difficult to change, therefore persisting in all primates.

Darwinism allows a second explanation: fitness. Primates with 10 digits may have been more likely to survive and have children than primates with eight. Vestigiality is a third explanation. Here, a physiological feature – the human appendix is one example – may have contributed to fitness in the past, but not any longer.

Vestige of the past

Similar kinds of explanations can be applied to our molecular structures – those that we use to metabolise food, synthesise proteins and procreate, for example. On Earth, all life (that we know of) manages genetic information in the same way by following something called the central dogma. Here, DNA "does" genetics: DNA is copied when we conceive children and translated to make proteins.

DNA, however, is not a good catalyst so is not used directly to catalyse chemical reactions important in metabolism. Rather, information in DNA is transcribed into molecules of RNA which act as messengers. The information in messenger RNA is then translated into proteins using a molecular machine called the ribosome, which is a mixture of RNA and protein. Proteins perform catalytic functions quite well, and so catalyse most of our metabolic functions.

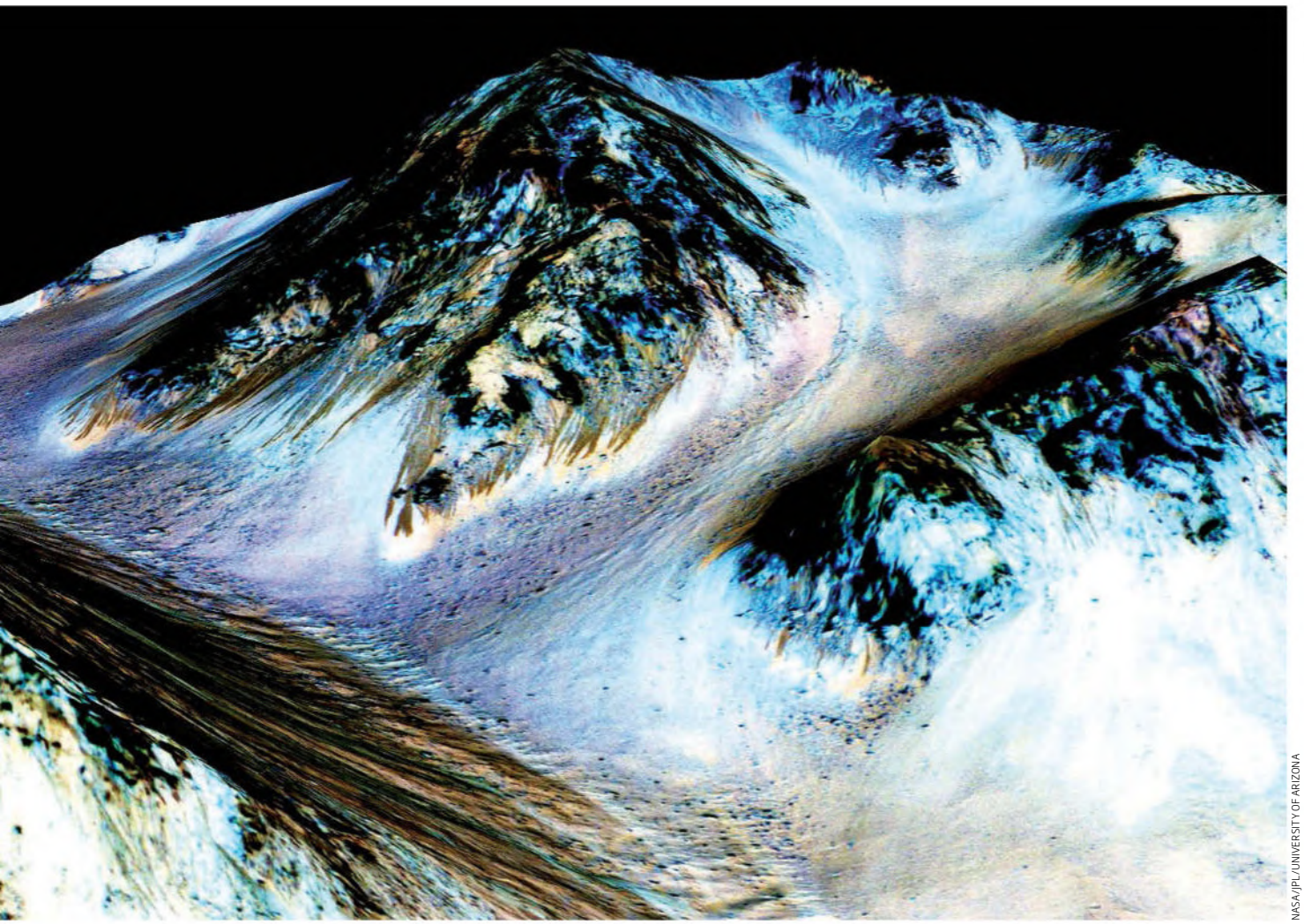
But not all. The RNA parts of ribosomes, not the protein part, make proteins. And RNA is found throughout life on Earth to help proteins catalyse metabolic reactions – for example, a piece of RNA must be attached to the vitamins niacin and riboflavin before they can function in metabolism.

These facts have been used to infer a model for the natural history of our molecular physiology. According to this model, life originally had neither proteins nor DNA, just RNA. In this RNA world, RNA performed both genetic and catalytic functions – somewhat poorly, perhaps, since RNA easily falls apart in water (bad for a genetic molecule) and has too few building blocks to be an effective catalyst.

Therefore, so the story goes, the RNA world invented DNA as a more stable genetic molecule. Then the RNA world invented proteins, which are built from a greater number of building blocks, to be better catalysts. RNA remained behind in life as a vestige of this earlier system, serving as a messenger between the two, in ribosomes and as parts of metabolism.

This way of managing information is everywhere in the biosphere so we rarely question it. But if we do ask "Why?" we realise that bioinformation management could have evolved differently. RNA is a bad catalyst compared with proteins because it is built from only four nucleotide building blocks. However, work in my laboratory over the last quarter century has shown that RNA need not be limited to these four. The bonds which pair the nucleotides in DNA and RNA follow some specific rules: size complementarity (big nucleotides pair with small ones) and hydrogen bonding complementarity (nucleotides that are hydrogen bond donors pair with hydrogen bond acceptors). We observed that natural RNA has not used all possible combinations of big and small, donor and acceptor.

If RNA had been constructed from the 12 different possible nucleotide building blocks it could be a better catalyst, more like proteins. Had Earthly life decided to expand the number of building blocks in RNA rather than inventing proteins, we could be living with a different information and metabolism management system today, one with just two biopolymers, not three. DNA would still be necessary because it is more stable and therefore makes a better permanent genetic molecule. But RNA in its expanded form could directly support metabolism.



NASA/JPL/UNIVERSITY OF ARIZONA

Unfortunately, we do not have access to a Simpsonian world where genetic molecules are built from 6, 8, 10 or 12 building blocks. We can, however, synthesise this world ourselves. We can go into the laboratory and make DNA and RNA from expanded genetic alphabets. We can then subject this system to laboratory Darwinism to show that it evolves. We recently did exactly this in collaboration with Weihong Tan at the University of Florida. Our expanded genetic system evolved in the laboratory to give molecules that bind specifically to breast and liver cancer cells.

This is one of the values of the emerging field of synthetic biology. We need not wait until we trip across a Simpsonian life form that manages genetic information differently. We can make one ourselves.

"We can go into the lab and make DNA from expanded genetic alphabets"

But we may not need to wait much longer for an alien example of a different informational biology. NASA has a rover on the surface of Mars searching for evidence of habitability. And in September NASA reported further evidence for flowing water on the surface of Mars. Both increase the chances that we will find alien Martian life.

But what molecular biology will those still hypothetical Martians have? We do not know, but if we must guess, those guesses must begin with estimating three probabilities: (a) the probability of life originating as an RNA world, (b) the probability that an RNA world might generate a ribosome to catalyse protein synthesis and (c) the probability that an RNA world might generate an expanded genetic alphabet to allow metabolism to be done by expanded RNA, not proteins. If (c) is more probable than (b), then most alien life will not have proteins. The protein-based life on Earth will be an exception. This is not an unreasonable estimate of the relative probabilities. After all, inventing ribosomes to make proteins by translation of messenger RNA is no small feat, especially if RNA with added building blocks is a better catalyst.

What would protein-free life look like? No one knows, but we can make some educated guesses. Life in the RNA world could easily have cells; back in 1989 my colleagues and I found evidence that the RNA world made lipids, which are key parts of cell membranes.

If Martian life and Earth life do not share a common ancestor since the time that the ribosome was invented, we may discover that Martian life has a molecular physiology different from the physiology we take for granted on Earth. Perhaps even eight-fingered yellow life. ■

There are strange forces at work behind our food desires. **Chloe Lambert** reports

GUT THINKING

YOU'VE just had a hearty lunch, but the doughnuts next to your desk are winking at you. You can't shake the thought of what the glazed, soft dough would taste like – and know that you won't be able to get on with your day until you have it.

On a basic level our relationship with food is simple – signals between the gut and the brain tell us when we're hungry, and when we are full. But experience shows us that the drive to eat is much more tangled and irrational. Some of that is down to the reward hit – the feeling of pleasure, mediated by the brain's reward centre – that we get from eating calorie-dense food like that glistening doughnut. Indeed, the effect of such foods has led some to liken our desire for them to drug addiction.

But we now know the gut itself, and also the microbes inside it, manipulate what we crave, painting a much more complex picture of the forces that determine the way we see food. Cravings could even be contagious – literally. When it comes to food, we're not as in control as we might think.

"People think we have much more conscious control over our eating behaviour than we do. There's a lot going on behind the scenes and it makes it very difficult to exert control on it," says Tony Goldstone, an endocrinologist at Imperial College London.

Even so, knowing about the forces that manipulate the way we think about food opens up new ways to regain control – for instance by retraining the brain or altering our gut flora. Fresh approaches would be more sensible than just expecting people to eat better, says Goldstone: "We don't just tell asthmatic people to breathe more."

What, when and how much we eat has typically been explained by two systems, one based on hunger and one on reward. The hunger system is mediated by hormones from the gut and from fat cells, which send information to the brain via the gut's own nervous system about when we last ate and how hungry we should feel. "We can eat very little one day, and a great deal the next, but this system works to ensure that body weight is relatively stable across the years," says John Menzies, a neurobiologist at the University of Edinburgh, UK.

MATT MURPHY

The reward system is more concerned with what type of food we eat. At its heart is the dopamine pathway, which seems to respond most strongly to foods that are high in fat and sugar. This is natural and necessary – it evolved to prompt us to seek out such food, helping us survive. "If we see a high-energy food, it pays to get it while it's available - a famine may be round the corner," says Menzies. "However, in our modern environment where food is abundant and cheap, the reward system may work against us, pushing us towards eating sweet and fatty foods even though we already have plentiful energy stores."

The brain even has its own calorie counter that drives our choices without us knowing, according to a recent study. Participants were shown pictures of 50 foods and asked how many calories they thought each contained, and then invited to bid in an auction for a chance to eat the foods. Regardless of their calorie estimations, which were often inaccurate, the individuals were more likely to bid for the foods that were truly the most calorific. MRI scans showed that activity in reward regions of the brain correlated with the true calorific content of foods – the more calories, the greater the reward.

Although these hunger and reward systems sound very different, there's a growing awareness of how interconnected they are. Some clues come from genetics. A gene called *FTO* is strongly linked to weight gain, and one variant of it raises a person's risk of becoming obese by 70 per cent. A recent study showed that such people have higher than normal levels of the hormone ghrelin, which is released by the gut, telling them they are still hungry after eating, but their reward system works differently too. MRI studies showed that this group's brains responded differently when they were shown pictures of food: the most pronounced differences being in the reward regions. The reward pathways in the brains of obese people have also been shown to respond less strongly to food – which could be driving them to seek out even more each time.

More evidence of the link comes from people who have had gastric bypass surgery – which reduces the capacity of the stomach and makes food pass more quickly into the small ›

RUNNING HIGH

They're hungry and exhausted – so why do runners often get a feeling of euphoria? It could be to do with the satiety hormone, leptin, or a lack of it. Leptin is synthesised in proportion to levels of fat in the body and after a meal it sends signals to the brain to say we are full, curbing appetite. But it is also an important regulator of dopamine in the brain, which triggers feelings of pleasure and reward (see main story).

To test its effects, Stephanie Fulton at the University of Montreal, Canada, and colleagues used genetically engineered mice that lacked a leptin-sensitive receptor and so had more dopamine. The mice lacking leptin ran almost twice as far and as fast as normal mice over the course of a day. Fulton believes that, during a run, falling levels of leptin send a signal to the brain to create feelings of pleasure and motivation. This mechanism may have evolved to keep us searching for food during periods of starvation, she says. "In the evolutionary past we had to move to get food – it wasn't immediately available so we had to chase it down. Leptin inhibits not just the consummatory part of feeding, but also the behaviour that's important to get access to food, including running."

Leaner people such as marathon runners, who have lower levels of circulating leptin, may be more susceptible to the rewarding effects of exercise, says Fulton. It could also help explain why people with low leptin as a result of anorexia are often restless and hyperactive.

intestine. After surgery, not only do people want to eat less, they experience a profound change in what they want to eat, finding they are drawn to much less calorie-dense foods. And brain scans of people before and after gastric bypass surgery showed altered activity in their reward centres. That contrasts with people who have a gastric band inserted. One explanation for these effects is that after a gastric bypass, food reaches the bowel much more quickly, so there's a faster hormone response, whereas a gastric band has no effect on hormone levels.

"These hormones are normally released after a meal to make us feel full, but as we're discovering, they also have effects on the way the brain works, to regulate the hedonic responses, the pleasure from food," says Goldstone. "The bypass patient will say, 'I'm not hungry, and I also don't want or like the food'. The band patient will say: 'I'm not hungry, but I could murder the chocolate cake'."

What if you could recreate these effects without the surgery? Susan Roberts, at Tufts University in Medford, Massachusetts, has designed a diet in which foods look like the kinds of calorie-dense treats people have learned to crave, but with a twist. "We basically confused people's reward system by giving them foods that had the flavour and appearance of high-calorie foods that are easily digested, but in fact they were lower calorie, slowly digested versions," she says. For instance, her diet includes a lower-calorie, slowly digested pizza, made with added fibre.

In a small trial, she scanned the brains of a group of overweight people before and after putting them on a six-month diet based on these foods. At the end of the study, the scans showed an increase in activity of reward pathways when the participants looked at pictures of healthy, low-calorie foods, compared with a group not eating the diet.

Risky rewards

"We were effectively retraining their brains," says Roberts. "You can think of pizza and you start craving pizza because you anticipate that rush of calories. If you eat the food and you fail to get the rush of calories, over time the reward circuitry adapts so it's no longer expecting a great zoom of carbohydrate coming in," she says.

The added fibre helped recondition cravings by making people feel full, but Roberts says it's also important that the participants only ate when they were truly hungry, to strengthen the reward they got from the food. And if dieters cheat and tuck into old favourites, it would strengthen the old reward pathways. Roberts is now beginning two larger clinical trials, and has commercialised the diet plan.

So we can retrain our brains to desire different foods. But we are also starting to better understand how the brain influences people who are driven to avoid food, such as those with anorexia. It used to be thought of as a mainly psychological disorder but it now seems that there might be profound changes in the brains of people with the condition. "These are biologically driven disorders," says Cynthia Bulik, a psychiatrist specialising in eating disorders at the University of North Carolina.

Many studies into anorexia and the brain hint that the same forces that cause some people to overeat might be at play in anorexia too, but having the opposite effect. For instance, recent research has found that the same genes that confer a high risk of obesity also seem to be involved in anorexia.

The exact mechanisms at work are still being investigated, but it could be that while those who overeat may have a dampened dopamine response, those with anorexia have a heightened, more sensitive one. "That may make all reward stimuli, especially those

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associated with food, overwhelming to them, and so their response is to pull away and not eat," says Caitlin O'Hara, who researches eating disorders at King's College London.

Another idea is that this group feel reward from things that most of us find unpleasant – like being hungry. "People with anorexia feel terrible when they're full," says Bulik. "Starvation actually calms their biology."

It's not yet clear whether this altered reward response is a cause, or a consequence of eating disorders. But finding that the condition could at least in part be down to brain changes opens new avenues for treatment. For example, a recent study at Kings College London on five people with severe, treatment-resistant

"Gut hormones modify not only consumption of food but also any drug of abuse"

Is your gut bacteria making you want to tuck in to cake instead of salad?

MICROBIAL MIND CONTROL

Your gut bacteria weigh more than your brain, and this mass of microbes could affect your mind. We know that transplanting the microbiota of anxious and normal mice switches their personalities, for example. Kathy Magnusson at Oregon State University has shown that feeding animals a high-sugar diet causes changes in gut bacteria that impair their cognitive flexibility – the ability to adjust to changing situations.

John Cryan at University College Cork in Ireland found that rodents fed a broth containing *Lactobacillus rhamnosus* showed reduced signs of stress and anxiety. This particular bacterium is known to release the anti-anxiety neurotransmitter GABA, and last month, Cryan's team presented work at the Society for Neuroscience meeting in Chicago that replicated this study in 22 men. They took the probiotic for four weeks and found similar results with regards to stress and anxiety.

In 2013, another study showed that healthy women who drank a probiotic milk product for four weeks showed changes in brain areas that process emotions. The team says this paves the way for work using probiotics to treat depression and other mood disorders.

anorexia suggests that stimulating a brain region involved in appetite and emotion regulation can help. Experimental treatments involving implants deep in the brain that stimulate the reward pathway when a person eats have also been successful for very severe cases.

While the brain clearly has a huge influence over what we eat, the influence of gut bacteria might be surprisingly large, too, and they can even affect our minds (see "Microbial mind control", above). Bulik's team has found stark differences in gut bacteria when people are in the acute stages of anorexia compared to when they have gained some weight. She thinks that during starvation, microbes that can survive on minimal calories flourish.

Gut microbes could have more pervasive effects too. Last year, Joe Alcock at the University of New Mexico in Albuquerque and his colleagues published a review of research on the microbiome and came to an intriguing conclusion – gut microbes don't just flourish on certain diets, they may also control our food cravings and preferences to serve their own purposes.

There are several ways they could do this. Animals' gut flora has been shown to affect their taste receptors, which changes their food preferences. And many gut microbes can produce proteins that mimic gut hormones. Alcock's team even thinks that changes in food preferences that people experience after bariatric surgery might be down to changes in gut microbes, not hormones.

That means interventions like probiotics, which help to change the composition of the microbiome, might be useful tools in regulating food cravings. And it suggests a varied diet would make it harder for any one type to flourish and exert control.

Because the faecal and oral microbiomes of families under the same roof are more similar than people who don't live together, the idea that food cravings are influenced by gut bacteria also raises the intriguing possibility that through the spread of these microbes, cravings could even be contagious. Of course, this similarity could be because the members of a household have the same diet. But it might also be that gut bacteria are spread person to person. We already know people are much more likely to become obese if they have a friend who is obese, leading some to speculate that the effect is not down to social contagion, but the spread of microbes.

More needs to be done to work out how strong all these effects are, but this new appreciation for the hidden forces influencing our perception of food has wide-reaching implications. Goldstone even wonders whether tapping into the connection between the hunger and reward pathways could alter appetites of a different kind. Animal studies have already shown that ghrelin increases intake of alcohol, nicotine and other drugs, while "fullness" hormones reduce intake.

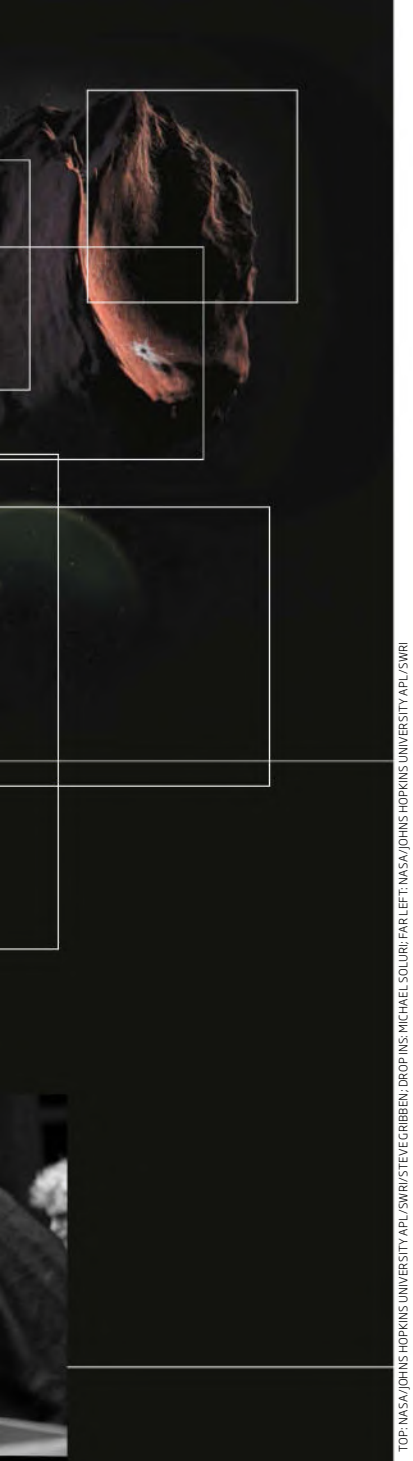
He suspects the same is true for humans. "We've shown that your nutritional state modifies the way the brain responds not just to food but also to winning money, and to stress," he says. "That's because the same reward circuitry is involved. There's evidence that gut hormones modify not only reward and consumption of food but also any drug of abuse – such as nicotine, cocaine, alcohol," he says. They are now beginning a large study.

At the very least, all this suggests that expecting people to rely purely on willpower to control what they eat, especially if they are obese, is misguided. "There's a cabal of obesity researchers that have turned up their hands and said the only thing you can do is rely on willpower," says Roberts, "I don't think it's worked for the last 30 years and it's not going to work next year either. Which is why we're trying to do it in a different way." ■

Chloe Lambert is a freelance writer based in London

Beyond Pluto

Gliding ever deeper into the wilderness, the New Horizons probe is set for one final hurrah before it falls silent forever. **Will Gater** reports



TOP: NASA/JOHNS HOPKINS UNIVERSITY APL/SWRI/STEVE GRIBBEN; DROP INS: MICHAEL SOLURI; FAR LEFT: NASA/JOHNS HOPKINS UNIVERSITY APL/SWRI

NASA mission control has already steered New Horizons toward its final destination

WITH Pluto rapidly shrinking from view, NASA's New Horizons probe is slipping further into a vast unexplored wilderness known as the Kuiper belt. This great frigid expanse beyond the gas giant Neptune is home to millions of icy bodies, known as Kuiper belt objects, many of which are thought to be pristine remnants from the birth of our planetary neighbourhood some 4.6 billion years ago.

As the world continues to gawp at breathtaking images of the Kuiper belt's most famous inhabitant, Pluto, the plucky little probe that snapped them is about to embark on one last fly-by. It won't be easy: New Horizons's latest target is much smaller than the dwarf planet and there is uncertainty about its exact position. But if all goes to plan, this valedictory mission could yet be the most revealing phase of an awe-inspring journey.

"The Kuiper belt is a truly key population for understanding how the solar system evolved after the planets formed," says Michele Bannister of the University of Victoria in Canada, who works on the Outer Solar System Origins Survey – a project to map the Kuiper belt from Earth to get a handle on how it formed. By capturing the first close-up views of one of its smaller inhabitants, New Horizons's final act before it falls silent could help rewrite the history of our cosmic neck of the woods.

This last assignment is far from an afterthought. In fact, the visit to a second Kuiper belt object was something the New Horizons team thought about from the outset, says John Spencer of the Southwest Research Institute in Boulder, Colorado, who is part of the planning team for the extended mission. "Back when the spacecraft was still being designed in 2002, we were thinking pretty seriously about what we would need to do."

Most importantly, the probe's designers made sure it would have sufficient fuel reserves to fire up the thrusters that would steer it towards another Kuiper belt object. "If we couldn't change course we would have no ability to get close to anything other than by the incredibly unlikely chance that we would just happen to breeze right by something," says Spencer.

The big question, though, was exactly what to aim for. Although estimates suggest there are hundreds of thousands of icy bodies in the Kuiper belt (see "Welcome to the boonies," page 36), the challenge was to discover objects within reach of New Horizons.

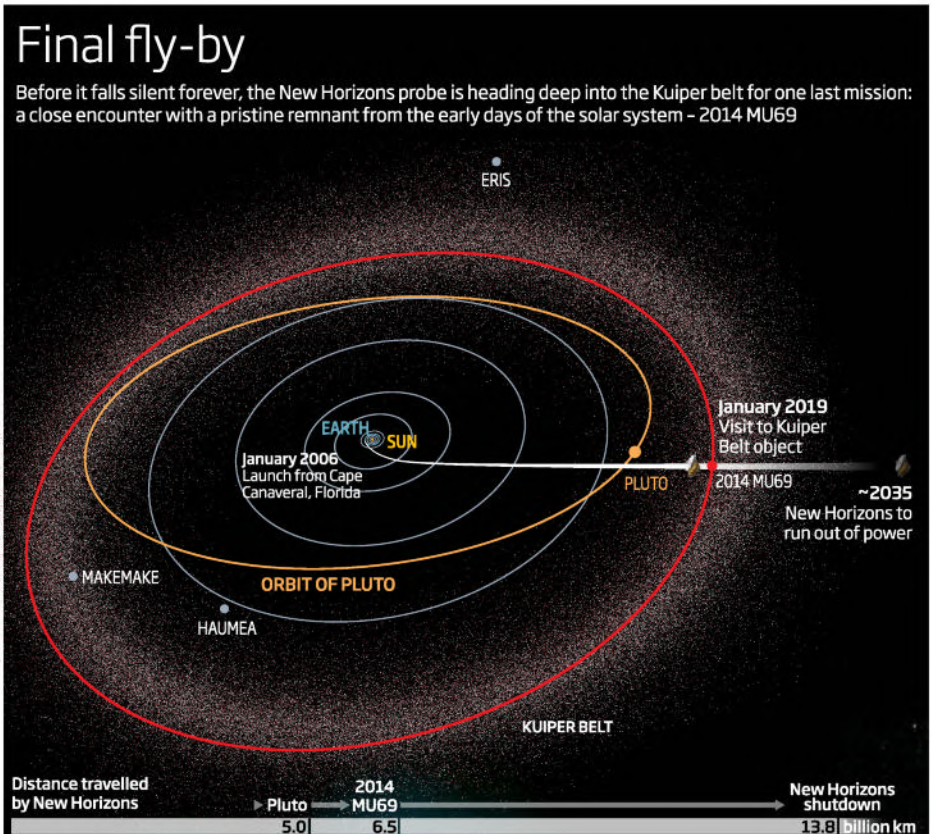
With Spencer at the helm, the search team started scanning the far reaches of the solar system in 2004, using the Subaru telescope in Hawaii. They wanted to check there was nothing large and interesting enough to warrant a tweak to the Pluto fly-by schedule. There was not. So two years later, when New Horizons was launched on its epic voyage, it carried enough fuel to explore a small portion of the Kuiper belt, but its post-Pluto destination was still unknown.

By 2011, with New Horizons set on a specific path, the team had a much narrower section of sky to scour, in the constellation Sagittarius. But now there was a fresh obstacle: it would be difficult to pick out faint objects against the myriad Milky Way stars in the background. "We were quite concerned by late 2013,"says Spencer. "We'd had three years of searching and we were finding it very challenging to look in the very dense star fields."

Eventually the group managed to discover some 50 Kuiper belt objects lurking in front of this sparkling backdrop. Unfortunately, all of them lay beyond the range of the outbound New Horizons. "I think the closest one that we found would have required about 50 per cent more fuel than we actually had in the tank," says Spencer. "We knew we were getting down to the ballpark of where we needed to be, but we certainly hadn't got what we needed at that point. That was why we turned to Hubble."

The Hubble Space Telescope promised more detailed images. But first the team had to prove to Hubble bosses that they stood a good chance of discovering potential targets, and then they had to sift though an avalanche of data. "It was nerve-racking," says Spencer, "but mostly it was just kind of exhilarating."

In 2014, the team finally struck gold: two Kuiper belt objects, 2014 PN70 and 2014 MU69, both of which would be within New Horizons's reach. The amount of fuel required to steer a course towards the former would have left precious little for precision manoeuvres around the object, compromising the ›



The New Horizons probe is about the size of a baby grand piano

WELCOME TO THE BOONIES

We suspected there were frozen badlands beyond the planets long before we saw them. In 1951, astronomer Gerard Kuiper made a strong case for the existence of a vast swathe of icy bodies beyond Neptune's orbit. It wasn't until 1992, however, that astronomers spotted something other than Pluto out there. It was the first real evidence of an immense ring of debris at the outermost edges of the solar system – a region now known as the Kuiper belt.

Astronomers have since discovered roughly 1500 Kuiper belt objects orbiting between 4.5 and 7.5 billion kilometres from the sun. And yet we've barely scratched the surface. We know that most of them are tens of kilometres across but there are a few larger bodies out there, including Pluto and its largest moon Charon. The dwarf planet Eris, for instance, appears to be almost the same size as Pluto, and might have similar geological activity. The region is also thought to be the source of most short-period comets, which take less than 200 years to orbit the sun.

But our best estimates suggest this planetary wasteland should contain hundreds of thousands of icy bodies – remnants from the solar system's early days – and we know almost nothing about all but a handful of them. "We are still pretty ignorant about many aspects of the Kuiper belt," says Wes Fraser of Queen's University Belfast, UK. "For one thing, we don't know much about what they are made of. They must have some sort of rock inside, but what is it?"

The Kuiper belt holds secrets about how the planets formed and how our planetary neighbourhood evolved. It might even provide insights into why Pluto didn't make it to planet status, says Fraser.

Trouble is, the region is so distant that even with space telescopes it has been difficult to get to know its inhabitants. No wonder planetary scientists are so excited by the prospect of a close encounter with one of them (see main story).

mission's scientific objectives, says Spencer. "So it was a fairly straightforward choice in the end." New Horizons would go to 2014 MU69.

The team is hoping that NASA will officially sign off on the extended mission to 2014 MU69, a decision that won't be made until late next year. But Spencer and his colleagues have already commanded the four engine burns needed to send the probe in the direction of its post-Pluto target, currently roughly 1.5 billion kilometres from the dwarf planet (see diagram, left).

Assuming the extended mission gets the nod, when the spacecraft visits 2014 MU69 in January 2019, we can expect to see an object very different from Pluto. Measurements of its brightness suggest it is between 30 and 40 kilometres across – far smaller than the 2370-kilometre-wide dwarf planet. It is also expected to be irregularly shaped and covered with craters, says Spencer. And as a member of the "cold classicals" group, which move in relatively circular orbits compared with other Kuiper belt objects, it should be reddish in hue.

Just as with Pluto, New Horizons's encounter with 2014 MU69 will be fleeting, and its instruments will have to work flat out to gather data on their icy quarry. "We'll be using our infrared spectrometer to map the composition of the surface and the ultraviolet spectrometer to look for any signs of an atmosphere," says Spencer. "We don't expect to see an atmosphere on something this small but we sure will be ready for surprises."

Atmosphere or not, getting up close and personal with 2014 MU69 should help to reveal whether Pluto was formed from such objects and could help to address fundamental questions about how planets form.

According to our best theory, planets are born out of protoplanetary discs – great whirls

JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/SOUTHWEST RESEARCH INSTITUTE (JHUAPL/SWRI)

SCOTT ANDREWS/GETTY

of dust and gas spinning around the midriff of a young star. The material comes together to form small clumps, which pull in more material thanks to their modest gravity. Soon you have the beginnings of planets, known as planetesimals, and eventually planets.

Objects like 2014 MU69, as residents of a region that has remained largely undisturbed since the early days of the solar system, are thought to be the ancient leftovers from this planet-forming process. "We would very much like to know what processes formed the primordial planetesimals – the original building blocks of the planets – and 2014 MU69 is the closest we have yet come to flying by one of these," says planetary astronomer Alex Parker, also at the Southwest Research Institute, who helped discover 2014 MU69.

Its relatively undisturbed location far from the sun – what Parker calls its "deep-freeze orbit" – has helped to preserve it as a time capsule. So this mystery chunk should tell us about the processes by which it was formed and how its ilk helped to build the planets.

Scars of violence?

If New Horizons observes fresh impact craters, for example, it may reveal something about the formation of bodies like Pluto. Any newish pockmarks will have uncovered material from below the surface of 2014 MU69 – stuff that hasn't been altered by cosmic rays, say, or ultraviolet radiation. That should allow us to figure out its composition, says Spencer. "We can compare that to what we expect objects like Pluto to have been made of."

Such observations could also help to solve another great mystery: how the solar system came to be arranged in its particular way. Current models suggest that the gas giants were once bunched up much more tightly than they are today, encircled by a substantial disc of planetesimals. Then something destabilised this cosy arrangement, hurling the planets into their present-day positions. The outer disc was shaken up too, although some of it endured to form the Kuiper belt.

Scientists have run many simulations of this period, and yet precisely how this process played out remains a conundrum. Was it a violent upheaval or a more gentle migration? To answer that, we need to know exactly how massive the disc of planetesimals was before the gas giants migrated. And here is where 2014 MU69's craters could help.

"In a way the craters actually preserve a reflection of the amount of mass that was around these objects at some point," says Wes Fraser of Queen's University Belfast, UK. The idea is that if an object is riddled with scars, that would suggest there were once lots of objects around to crash into it, whereas if an object has only a few craters, it was probably surrounded by fewer objects. By studying the sizes and numbers of craters in New Horizons's images, scientists should get a better idea of the mass of the disc. And by feeding that back into current models, they should get a clearer picture of how the solar system evolved into what we see today.

For Bannister and her colleagues at the Outer Solar System Origins Survey, the fly-by could also provide context for their studies of the orbits and surface compositions of distant Kuiper belt objects. "We can finally match together what we see from Earth only as a tiny point of light with the actual ices and hydrocarbons that cover its surface," she says. And although 2014 MU69 will undoubtedly be the centre of attention during this post-Pluto mission, the team behind New Horizons will also study other objects the probe glimpses.

As for the little probe itself, once it has completed its work in the Kuiper belt, it will glide ever further into the outer reaches of the solar system. It will continue to send back data, including measurements of the solar wind – the stream of charged particles flowing from our star – until its radioactive power source runs out, probably in the mid-2030s.

Regardless of when we lose touch, New Horizons's fate is set. With the Kuiper belt frontier traversed, it will drift off into the Milky Way – its precious data stored on Earth and its journey into darkness complete. ■

Will Gater is an astronomy journalist based in Somerset, UK

WHERE SPACECRAFT GO TO DIE

Once New Horizons has slipped past its latest target in the Kuiper belt, its course will whisk it deep into the Milky Way. It will follow an armada of space probes that have sailed into quiet retirement or crashed into violent oblivion.

Like New Horizons, the two Voyager spacecraft – which toured the outer planets in the 1970s and 1980s – are heading for interstellar space. And data returned by Voyager 1 has led some to argue that it has already left our solar system.

Others have gone out with a bang. The Galileo probe to Jupiter was commanded to plummet into the gas giant so as not to litter the planet's moons with earthly debris. And the Rosetta mission, currently hovering around the comet 67P Churyumov-Gerasimenko, will be deliberately crashed into its icy quarry next year. A similar fate awaits Cassini, due to plunge into Saturn in 2017.

A few spacecraft are lucky enough to retire on the planet they went to see. When the adventures of the Mars rovers Opportunity and Curiosity eventually come to an end, for instance, they will sit motionless on the Red Planet's surface, slowly gathering ochre dust as the Martian breeze swirls around them.

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SPENCER WILSON

SUPER SILICON BROS

Our electronic devices rely on it, but silicon is deeply flawed. Could one of its secret identities save the day, asks **Tien Nguyen**

IT'S a material so good they named a valley after it. And no wonder. Today's connected society would be impossible without silicon. Chips made from it run everything from smartphones to pacemakers, with some 6.5 million square metres of the stuff rolled out every year. And the solar industry relies on vast quantities of silicon to make the photovoltaic cells that convert light into electricity.

Silicon is in such demand that you'd be forgiven for thinking its position at the top of the pile was untouchable. But its status owes more to the fact that it is the second most abundant element on the planet than to its performance. Crucially, silicon's atomic structure limits its ability to conduct electricity. And that holds back computer processing speeds and the efficiency of solar panels. If electronic devices are to get faster, cheaper and more compact at the rate we've come to expect, silicon as we know it needs to be shown the door.

So the hunt is on for a replacement. Many elements and compounds have been proposed over the years, but it is starting to look like the solution might be closer to home. Ordinary silicon, imbued with certain superpowers, might be able to replace itself.

Silicon belongs to the semiconductor family of materials, whose ability to carry an electric current lies somewhere between that of a metallic conductor and an insulator. In a computer chip, applying a small voltage is enough to flip silicon's state between conducting and insulating, producing the binary 1s and 0s of digital information. This control over the flow of electrons, combined with its low cost, stability and high availability, has made silicon the material of choice in electronics for over 60 years.

The trouble is, conventional silicon chips are about as good as they are going to get. A top-of-the-range chip today squeezes in around 5 billion transistors – the basic on-off switches that control the flow of electrons. That's close to the upper limit. Try to pack in many more, and material defects combined with the heat produced by all the transistors switching simultaneously start to adversely affect a chip's efficiency. This is the main reason why processor speeds have more or less stalled in the past decade. "Electronics has pretty much reached the peak of its performance," says Lok Lew Yan Voon, a semiconductor physicist at the Citadel, the Military College of South Carolina in Charleston.

Place in the sun

When it comes to solar panels, silicon's prospects look even dimmer. "Silicon is not very good at absorbing light," says P. Craig Taylor, director of the Renewable Energy Materials Research Science and Engineering Center at the Colorado School of Mines.

To understand why light presents a problem, it helps to know a little about what makes silicon a semiconducting element in the first place. According to the rules of quantum mechanics, the electrons within a material can't have just any old energy, but must occupy one of a set of well-defined energy levels. Electrons at lower levels remain bound within their individual atoms. Those at higher levels, meanwhile, are free to move around, allowing them to carry a current through the material.

In a metal such as copper, the atoms' energy levels overlap, so electrons can move freely all the time. But in a semiconductor such as silicon, the electrons need a shove to lift them from a low to a higher energy level. In a ›

chip, the energy required to bridge this "band gap" and generate a current can be supplied in the form of a voltage; in a photovoltaic cell, the energy comes from a photon of light.

But it needs to be the right sort of light. Some portions of the spectrum, such as infrared light, don't provide enough energy, while others provide too much. This means that about half of the sunlight that strikes a silicon solar cell is essentially wasted.

And it's not just about energy. Silicon is what is known as an indirect band-gap semiconductor, meaning its electrons don't generally have quite the right amount of momentum to make the leap into the higher states unaided, making the transition even less likely to happen. The upshot is that conventional silicon solar cells are hampered by low efficiency.

The pretenders to silicon's solar crown are led by semiconductors that only need one jump to become conductive – those with direct band gaps such as cadmium telluride and gallium arsenide. But these materials have their weaknesses. Many of their constituent elements are rare or expensive, or are toxic heavy metals, such as cadmium and arsenic, that present a threat to the environment if not recycled carefully.

For computer chips, there is a similar lack of convincing replacements. A lot of money has been pumped into graphene, a wonder-material not only stronger and lighter than steel, but capable of transporting electrons across its surface at speeds far greater than in silicon. But graphene is difficult to make in quantity and doesn't work as a semiconductor.

Expensive, toxic, hard to make: these aren't exactly properties that recommend a material, especially if you're going to need vast quantities of it. "For things like solar panels, if you're going to cover half the state of Arizona, you need something that's abundant and relatively inexpensive," says Taylor.

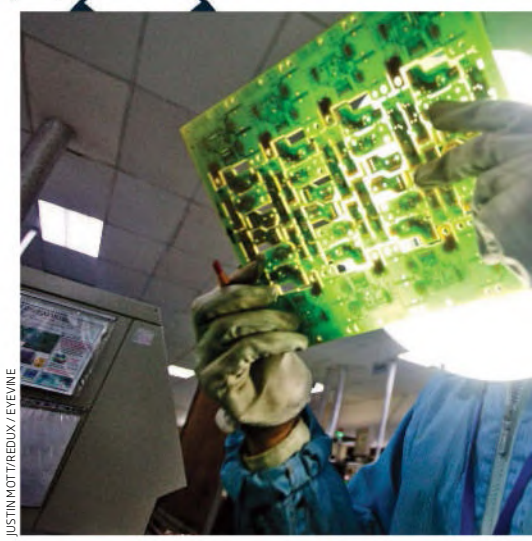
A dream would be to find a way to turn ordinary silicon – non-toxic, readily available and equipped with a huge industrial set-up dedicated to working with it – into something that matches the best traits of these other materials. As it turns out, such a transformation may already be possible.

An element's properties vary dramatically according to how its individual atoms are arranged. Graphene, for example, is a two-dimensional lattice of carbon. Arranged differently, the same atoms make dazzling diamond or dull, pencil-lead graphite.

Such different forms, or allotropes, of an element are by no means limited to carbon. Under ordinary conditions, silicon atoms adopt an essentially cubic arrangement similar to that of diamond. But up to a dozen alternatives are possible, according to some estimates, each with different and potentially useful properties.

Silicon enhancement

One researcher aiming to see if these silicon dreams can be made reality is Timothy Strobel at the Carnegie Institute of Washington. Last year, he and his team announced they had made a new silicon allotrope that could avoid the band-gap problem with just a squeeze. The discovery came almost by accident: the team had compressed elemental silicon and sodium together to create a shiny, blue-tinged crystal of Na_4Si_{24} and wanted to measure the compound's resistance to the flow of electrical current.



JUSTIN MOTT/REDUX / EYEVINE

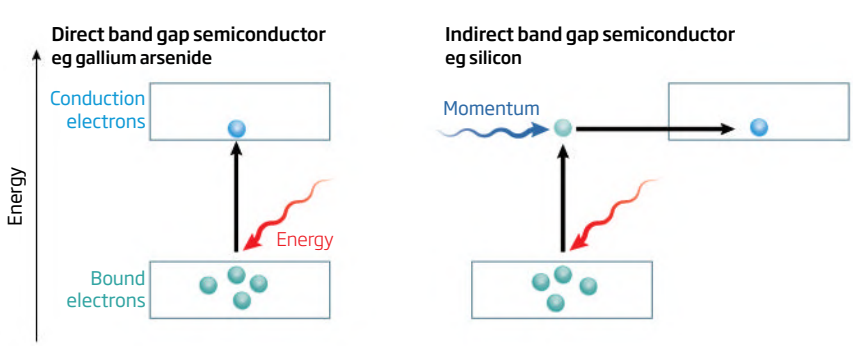
Getting accurate measurements meant attaching electrodes to the crystal with a glue, which required heating in order to set. "We put it in the oven, measured the resistivity, and we kept getting these crazy results we couldn't understand," says Strobel. The data suggested that temperatures as low as 40 °C were enough to bake sodium ions off the structure and change its electrical properties. This was an unexpected result, as similar compounds generally form networks of silicon cages in which the smaller sodium atoms rattle around, unable to escape even at high temperatures. But instead of cages, Na_4Si_{24} forms corridors, allowing sodium ions to slide out easily as the heat rises (see illustration, below right). Heating to 100 °C brought the sodium levels down to less than one atom in a thousand, making a bona fide allotrope of silicon – Si_{24}.

"The really cool thing about the material we've made is that it's the closest thing to a direct band gap material," says Strobel. While it is still officially an indirect band gap semiconductor, applying a little physical strain is enough to open up a direct pathway across the band gap, allowing electrons to make the jump with no need for a change in momentum. "You just need to squish it by 2 per cent," says Strobel. This could theoretically be done by growing Si_{24} on a template with slightly different dimensions, like a person being squeezed into an ill-fitting suit.

This has the potential to make a much more efficient solar cell, since more energy can go directly to moving electrons successfully. What's more, Strobel and his colleagues think it will be possible to scale up production of Si_{24} to industrially useful levels – great news for

Silicon's fatal flaw

Semiconductors like silicon are hard to kick into action because their electrons need extra momentum as well as energy to get them going. The hunt is on for alternative forms of silicon that act more like direct band-gap semiconductors



Silicon is used in 90 per cent of electronics and almost all solar cells

the rapidly growing photovoltaics industry.

The very best silicon solar cells today convert just 25 per cent of solar energy into power, some way off the widely assumed upper limit for solar cells of 33 per cent. Si_{24} could bring cells closer to the upper limit, but who says we couldn't go further still?

The figure of 33 per cent is based on an assumption that each incoming photon of light liberates just one conducting electron. But when quantum effects come into play, some materials can extract enough energy to excite more than one electron at a time. In 2013, Giulia Galli of the University of Chicago and her colleagues proposed that nanoparticles of a silicon allotrope known as BC8 would be able to harness this property, converting up to 42 per cent of incoming sunlight into electrical energy. Strobel and others are now working to test this – although Galli cautions that they are exploring largely unknown territory as yet.

But it's not all Si in the sky. In the world of computer chips, another silicon allotrope has been making breakthroughs. In February, Deji Akinwande and his colleagues at the University of Texas at Austin announced that they had built the first functioning transistor made from one of silicon's most exotic forms – silicene.

Like graphene, silicene owes many of its desirable properties to being a single, two-dimensional layer of the element. But whereas graphene is entirely smooth, silicene's structure buckles as its larger silicon atoms struggle to squeeze into the same regular arrangement. In both cases, the generally flat, honeycomb structure results in extra unbound electrons that hover above the surface, allowing them to travel faster than in the cubic lattice of ordinary silicon. "I'm not talking about two or three times faster," says Lew Yan Voon, who named silicene and predicted its properties back in 2007. "I'm talking about a million times faster."

Travelling in these fast lanes across the surface would also lead to fewer collisions for the speeding electrons, significantly reducing the amount of heat that a densely packed chip would produce. And as transistors built from silicene can be made much thinner than those in existing chips, many more could be squeezed into the same space.

The device Akinwande's team built is just a proof of principle, showing only modestly improved speeds. And there are major hurdles to overcome before we'll find anything similar in our smartphones. The same two-dimensionality that should make silicene faster also means it readily falls apart; the transistor lasted just a few minutes. Nor is the material easy to make: synthesising it requires a high vacuum set-up and specialised expertise. "It's more like an art," says Lew Yan Voon. "Some people can do it without thinking, and some are still struggling to make it."

Still, it's a start. "Up until last year, people thought it wasn't possible to make a device from silicene because of its instability," Akinwande says. "So we were very excited and very lucky to get results." For all the caveats, Lew Yan Voon agrees. "The fact that you can actually make a device with silicene is a big breakthrough", he says.

"I don't mean two or three times faster. I'm talking about a million times faster"

Direct band-gap allotropes such as BC8 and Si_{24} could also have a part to play in the future of electronics, possibly enabling the integration of optical and electronic components onto a single chip. That is the dream scenario, Strobel says. Such hybrid chips could transmit signals using light as well as electrons, greatly increasing their speed as well as the amount of data they can carry.

It is too early, though, to know how these new forms of silicon will shape up. We have been here before, after all. A decade ago, there was great excitement over the potential of quantum dots, tiny crystals of regular silicon that harnessed quantum mechanical effects to upgrade their light absorption. But no one could get them to generate a current effectively and they soon fell out of favour.

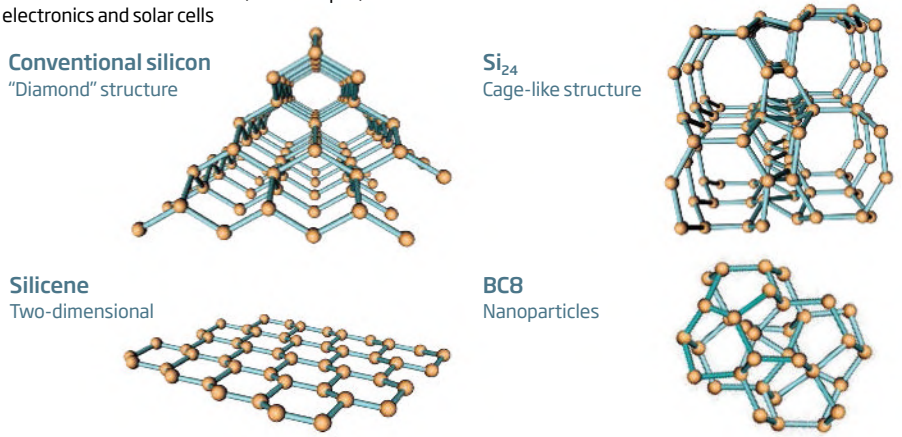
This time it's different, Taylor thinks. A few months after Akinwande's success, he organised a conference on exotic forms of silicon to discuss advances in the field. "The feeling within the community, and certainly at our conference, was that the time was right to really push ahead," he says.

If structures like silicene, BC8 and Si_{24} prove viable for solar cells and chips, they will tie together the promise of exotic materials with the safety, low cost and dependability of silicon. Swapping one form of the element for another might not sound like a big change. But this simple casting off of a disguise, like Clark Kent taking off his glasses, might superpower the world. And the valley wouldn't even have to change its name. ■

Tien Nguyen is a writer based in New York City

Secret identities

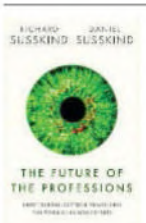
Silicon can take several forms, or allotropes, some of which could revolutionise electronics and solar cells



Birth of a new order

An unstoppable wave of automation is set to break over the professions. Can they, will they, survive, asks **Pat Kane**

The Future of the Professions: How technology will transform the work of human experts by Richard Susskind and Daniel Susskind, Oxford University Press, £18.99



"COMPUTER says 'no'." Let's hand it to the BBC's cult comedy *Little Britain* and its grumpy creation Carol Beer, who was fond of quoting computer "judgements" on matters she could easily have decided herself. With cruel precision, it laid bare our cultural nerve endings about the dangers of too much automation in the expert services we seek.

We would struggle to call her a "professional" in the same vein as those that Richard and Daniel Susskind discuss in *The Future of the Professions*. But empathy – the capacity to read another human sensitively that is the root of our moral compass – is one of the few aspects of professional roles that the Susskinds imagine might survive "incremental transformation" by information technology.

Brought together, the Susskinds (father Richard and son Daniel) are well placed to comment. Daniel, a lecturer in economics at Balliol College at the University of Oxford, and a former UK Cabinet adviser, and Richard, IT adviser to the Lord Chief Justice, bring a first-principles (and historical) approach to the question of why we need professionals at all.

Faced with legal issues, health challenges, educational needs, financial complexities, and the building and engineering of their environment, the citizens of the Middle Ages couldn't possibly know what was required to make informed decisions. The professions – lawyers, doctors, teachers, accountants, architects, engineers and so on – emerged to answer this need, with what the Susskinds stress is their common offer: practical expertise.

Today, information networks provide access to such expertise, while radically bypassing the professional gatekeeper, in ways that make people feel more personally empowered. Thus we turn up at our doctor's surgery with more web-collated information on our persistent leg wound than a field paramedic. And if search engines struggle to turn up the answers we seek, we enter the jungle of user forums where we interpret and judge the practical opinions of others. This amounts to the devolution of classic professional competences.

And if all this cyber-centricity puts irreparable strain on our relationships, we can kick off divorce proceedings by formulating the relevant legal documents online – completing the routine tasks with what might be, under the circumstances, a welcome impersonality.

The Susskinds map out a teeming "vanguard" of post-professional innovations in opening chapters that are themselves worth the price. "Ingestibles" – pill-like monitors powered by stomach acid – will beam your stats automatically to alert medical expert systems, which will autonomously make an initial but well-referenced assessment of your condition. Elsewhere, the authority of religious clerics of all faiths faces a challenge from social apps as they distribute texts and host discussions – on "Psalm Pilots". Journalists look gloomily on computerised auto-hacks who write serviceable sports and financial prose. And as for lawyers, Shakespeare's request to kill them all looks close to being answered – at least for those particular meat machines involved in researching case law.

"Pill-like monitors powered by stomach acid will beam your stats to alert medical expert systems"

The eBay software already resolves 60 million disputes per year without the involvement of a single lawyer – more than 40 times the number of civil cases registered annually in the courts of England and Wales. And more students sign up for Harvard's online courses in a year than have ever attended its campus.

ALESSIA GIULIANI/EYEVINE

With confessional apps and online discussions, will priests survive?

JANINE WIEDEL

The Vatican has even launched an official app to help sinners prepare for confession (though with the usual proviso that it is no substitute for the real thing).

"This debate is not about what's best for you," Richard Susskind warned an increasingly agitated audience of professionals at an event to mark the book's release in University College London's Kennedy Theatre last month. "It's about what's attractive for recipients." By the time the distinguished panellists assembled for the event were due to speak, the mood in the hall resembled that of the proverbial turkey farm recently privy to the

Should machines encroach on sensitive areas such as deliveries?

true significance of Christmas. But the panellists' confidence in the uniqueness of their individual cases was undimmed.

Michael Briggs, a judge in the Court of Appeal of England and Wales, welcomed the efficiency that machines could bring to the legal profession, but stressed that clients would never choose smart software over a lawyer with moral principles at heart. And David Lomas, head of UCL's School of Life and Medical Sciences, asserted with equal confidence that machines could never match the trust relationship that patients require from their doctors.

Given the increasingly high costs of accessing legal assistance and the unavoidably high false-diagnosis rates among doctors, one cannot help but wonder whether the public truly shares the concerns over technology that some so readily attribute to them.

As the professionals in the hall piled in with frantic justifications of their own indispensability, the authors' frustration was palpable. When one doctor took to the floor to say machines would never be able to deliver babies, Richard Susskind cut in to explain that it was no longer a question of whether or not they could encroach into such sensitive areas, but whether they should.

Instead, stress the Susskinds, the debate we must have before it is too late should centre on where we place the moral boundaries. Should a robot judge ever be given authority to pass death sentences, or a digital physician advise a family on when to pull the plug on a relative's life-support system?

The unusually patient explanations in *The Future of the Professions* give a sense of the official pushback that the authors have encountered. Richard Susskind recalls being censured by the UK Law Society for "bringing the legal profession into disrepute". His crime? A mid-1980s prediction that email would become a natural medium for lawyer-client relations.

"Human professionals are no longer the 'sage on the stage' but the 'guide on the side' "

As creator of the world's first commercial "expert" legal software in 1988, the elder Susskind loves the renaissance of applied AI. In a world where a new medical paper is published every 41 seconds, the vast data-crunching of learning machines such as IBM's Watson or Google's DeepMind would not just provide a safety check for the judgements of human professionals, but also make fresh diagnoses.

The Susskinds foresee the professions being "decomposed" into their various tasks and scattered across new divisions of labour such as "process analysts", "knowledge engineers" and "system providers". "Quasi-trust" is all that would be required for open networks of expertise shaped by reputation and ratings to flourish: think eBay, Airbnb or Uber.

In this new compact of digital access, DIY enthusiasm and ever-smarter machines, human professionals are no longer the "sage on the stage" but the "guide on the side". No doubt the traditional credentialing (and the occupational ego) of the lawyer, doctor or teacher will have to change.

The writers leave a meaty role for "craftspersons", those professionals whose rare talent and sensibility can still surpass the capabilities of the coming matrix – though in a scenario in which AI is embedded throughout our social exchanges, it's hard to see how they will be anything other than relics.

Amid all this pitiless future shock, in which entire traditions of professional work unravel before relentless learning machines, it comes as a surprise to hear the social vision that the Susskinds prefer.

Collective future

The authors ask readers to perform the "blind veil" test of philosopher John Rawls. You are given two policy options, with all prior knowledge about them or their advocates stripped away: which do you prefer?

One post-professional route "leads us to a type of commons where our collective knowledge and experience, in so far as is feasible, is nurtured and shared without commercial gain". The second route "takes us to an online marketplace in which practical expertise is invariably bought and sold".

The Susskinds go for the former, unequivocally – which may make the book's endorsees from PwC and Deloitte blink, at least once.

If she took empathy classes, Carol Beer could still draw a paraprofessional wage in the coming years. But she might also have to listen to what her devices are actually telling her. "Computer says: 'Shall we?'" ■

Pat Kane is the author of *The Play Ethic* and a curator at Nesta's FutureFest. Additional reporting by Gilead Amit

One small step for robots

For humans to gain a new geographical and commercial hold in space, we're going to need some help from robotic hands. **Katharine Gammon** investigates the jobs that are building the future of space exploration

In recent movie *The Martian*, an astronaut is left behind on the red planet with only his wits and scientific prowess to keep him alive. In reality, it is robots that are the first – and deepest – explorers of any new space territory and they're leading the way for small businesses to get into the new world of commercialized space.

According to a 2014 report by the Space Foundation, the world of commercial space infrastructure and services is now worth $250 billion – and growing, with private companies like SpaceX and Virgin Galactic its most notable players. "Space robotics is absolutely primed to grow," says Chris Lewicki, president and chief engineer at Planetary Resources, a company based in Redmond, Washington, that plans to use robots to mine asteroids. "The ability to deploy systems and learn more about the world around us will be increasingly in demand as time goes on."

Digging on Mars

While it's certainly a niche field, jobs in the commercial space robotics industry are expected to increase. William Pomerantz, vice president of special projects at Virgin Galactic, is currently working on the development of the LauncherOne satellite launch vehicle, which will send small satellites into space. He is optimistic about the growing number of opportunities for STEM graduates: "The choice used to be between a government civil space agency or a military space agency. Now, you can go and work for a start up, or create your own. You

can do a Kickstarter to launch a satellite into space."

Getting a job in this field requires a multidisciplinary approach and a willingness to shift gears quickly, says Stephen Indyk, a project engineer in mechanical systems at Honeybee Robotics, a company based in Pasadena, California, that builds robotic tools and systems to be used in space.

Indyk works on a project that sends commands to a tool on the Mars rover called the Rock Abrasion Tool (RAT), a surface grinder for rocks. When scientists want to know the internal composition of a rock, the team deploys commands to the RAT to cut it open. A second device also exists in a vacuum chamber on Earth, where commands can be tested before deploying in space. On a typical day, Indyk might create commands and run reviews for the instrument on the rover, or he might start testing another project.

"In the past, I have tested rock grinding tools for potential use on future Mars or moon missions; designed, built and tested a coring drill for potential Mars use; and led test programs for studying sample retrieval of comets," he says. "One thing all the different stages and phases of projects have in common is that the days can be long and the work requires a great understanding of the project goals."

The ability to pivot between projects is essential, as they can be both long in scope, – decades, even – and short in timespan: sometimes as little as a few months.

Fly me to the moon

For small companies that are creating the next generation of technology that will work alongside NASA missions, pivoting is equally important. Steven Huber is chief operating officer at Pittsburgh-based Astrobotic, a company that promises to deliver payloads – anything from scientific instruments to personal mementoes – to the moon for a per-pound fee. Over the past six years there, he's seen a lot change. "When I started, I expected the opportunities to be at NASA and JPL, but small companies have a lot of opportunities right now," he says.

Astrobotic is currently working toward building up the lander (an automated vehicle that can land on the moon) for its first mission. Teams are building a new version of a computing and navigational sensor that will be used to land on the moon's surface.

Another company pioneering ambitious leaps in the field is Planetary Resources. In July, the company deployed its first spacecraft from the International Space Station (ISS). It plans to launch ambitious probes over the next few years, leading to asteroid mining in the next decade. Water from asteroids could help astronauts create fuel in space and protect them from radiation, while metals like nickel and cobalt could help humans create structures in space. They are also developing additive manufacturing, an advanced form of 3D printing that would allow mined materials to be used to build structures wherever needed.

For Jonathan Goff, founder of Altius Space Machines in Broomfield, Colorado, there is a lot of potential in space robotics, but "most of us are still selling robots to NASA," he says, adding that Earth-based robotics can be a good jumping-off point for entry into the field.

Altius is currently building robotic arms to be used on the ISS. The company is also building a biomedical robot that can be used on Earth or in space. "There is so much room for the robotics industry to grow in space," Goff says. "Right now, we don't assemble or fix anything in space – and that's going to change."

Huber believes private companies are able to try new things cheaper than NASA can. "In a small business environment, there is the opportunity to take risks and try out ways to do things cheaply and quickly," he says. "In a government structure, projects tend to be larger and there's a disincentive to take risks."

> "Internships are low risk for the individual and for the organizations"

Although some of this technology is still years away, progress comes day by day, says Lewicki. "We often look at making that step forward as one giant leap, but we can make progress every week, month and year toward our goal," he says. Pomerantz agrees: "The space industry is catching up with Moore's Law and the fact that in every other electronic industry things are getting smaller, faster, cheaper and ubiquitous, which just didn't happen in space for decades. That's finally starting to come into play, and it's thrown open wide this door to space."

Stepping into the lab

So, how do you get into this world? For Indyk, it was a family connection to early space robots – his great-uncle was chief engineer of the lunar rover during the Apollo missions – that sparked his interest. During his college years at Rutgers University, where he studied mechanical engineering, Indyk honed his skills by doing robotics in research labs and interning at NASA's Goddard Space Flight Center. "Internships are low risk for the individual and for the organizations. If you're a student, you get to try on the career and see how you like it," he says. During one of his internships, he worked on a robotics system that could service satellites in orbit.

> "In a small business environment there is the opportunity to take risks"

Another way to explore opportunities is by joining student organizations such as Students for the Exploration and Development of Space (SEDS). Pomerantz credits the US chapter of the organisation, where he now sits on the board, as providing his first real introduction to careers in space, while studying planetary science as an undergraduate at Harvard University. He advises anyone interested in this industry not to be put off by the image of the typically brainy rocket scientist – when interviewing potential Virgin Galactic candidates, he looks for those whose experience demonstrates some technical ability, such as building CubeSats or drones, whether as part of a university course or a self-directed project. Crucially, these projects allow candidates to show how well-rounded they are. "Those students are coming to us, and not only have they demonstrated some real engineering capabilities, but often because of the nature of the project, they've had to do some fundraising, project management, recruiting and media outreach," he says.

For STEM graduates looking to enter the field, Huber suggests getting broad hands-on experience working on projects with a variety of different disciplines. He adds that it's great to specialize in one area, but it's also important to understand other things – so if you're a mechanical engineer, you should also be knowledgeable about the software and electrical side of things. "You will be better at what you do by understanding what other people do and being able to see the problems from a lot of different perspectives." ■

Katharine Gammon is a freelance science writer from Santa Monica, California

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University of Waterloo | IQC Institute for Quantum Computing

Faculty Position

Applications are invited for 1 or more tenure-track faculty positions, at the rank of Assistant Professor in the Institute for Quantum Computing (IQC) and any department in the Faculties of Mathematics and Science. The IQC is a collaborative research institute focused on realizing quantum technologies including sensors, actuators, quantum communication, and information processors. Membership in IQC is renewable, with an initial appointment of 5 years, and comes with research space, a teaching reduction of one course and a stipend. Only those candidates whose research program directly connects with the goals and ongoing research in IQC will be considered. Information about research at IQC can be found at **http://uwaterloo.ca/iqc/research**.

A PhD and significant evidence of excellence in research in quantum information science and technology and the potential for effective teaching are required. Responsibilities include the supervision of graduate students, as well as teaching at the undergraduate and graduate levels. Based on qualifications, salary range of $75,000 to $155,000 will be considered. Negotiations beyond this salary range will be considered for exceptionally qualified candidates. Effective date of appointment is negotiable. The search is open to all areas of quantum information. The search committee will consider all creative and energetic candidates in any area of research focused on advancing quantum information.

The University of Waterloo is host to the Institute for Quantum Computing. At present, IQC has a complement of 22 faculty members (growing to 33) from the Faculties of Engineering, Mathematics and Science. Interested individuals should upload their application via the faculty application form at: **http://uwaterloo.ca/iqc/positions**.

The application review process will begin on **December 1, 2015** and continue until **March 31, 2016**.

The University of Waterloo respects, appreciates and encourages diversity. We welcome applications from all qualified individuals including women, members of visible minorities, Aboriginal peoples and persons with disabilities. All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority.

Three reasons to apply: **https://uwaterloo.ca/watport/why-waterloo**.

Kansas State University

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Kansas State University

The Department of Physics at Kansas State University seeks a faculty member to join its physics education research (PER) group. Experience with research on the teaching and learning of physics that complement and/or expands the existing PER efforts at KSU will be considered favorably. The successful candidate will be appointed at a rank of tenure-track Assistant or Associate Professor in the Physics Department. Candidates must present credentials which will justify appointment at one of these levels. Minimum requirements include a Ph.D. in physics education research or equivalent and research experience beyond the doctorate.

The Department has an outstanding physics education research program (KSUPER), which was founded in 1972. At present KSUPER includes two faculty members. A detailed description of research activities, post-docs and graduate students in KSUPER can be found at **http://www.phys.ksu.edu/ksuper**. For further information contact Eleanor Sayre (**esayre@phys.ksu.edu**) or Dean Zollman (**dzollman@phys.ksu.edu**).

The successful candidate will also demonstrate a strong commitment to teaching and mentoring of students and to serving a diverse population. He/she will be expected to obtain external funding for research activities, collaborate with other faculty in physics and other academic departments and build a national and international reputation in PER.

Applications should be sent, to **PER Search Committee, 116 Cardwell Hall, Kansas State University, Manhattan, KS 66506-2601** or to **persearch@phys.ksu.edu**. Applications should include a cover letter that addresses qualifications for the position, a curriculum vita, and statements of research and teaching interests. The applicant should arrange to have three letters of reference sent to the address above.

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University of Waterloo | IQC Institute for Quantum Computing

Research Assistant Professor

Applications are invited for a Research Assistant Professor position in the Institute for Quantum Computing (IQC) and any department in the Faculties of Mathematics, Engineering and Science. The IQC is a collaborative research institute focused on quantum information, science and technology. Membership in IQC is a five-year appointment, subject to re-evaluation after three years taking into consideration performance and availability of funding. Only those candidates whose research program directly connects with the goals and ongoing research at IQC will be considered. Information about research at IQC can be found at **http://uwaterloo.ca/iqc/research**.

A PhD and significant evidence of excellence in research in quantum information science and technology are required. Based on qualifications a salary range of $70,000 to $90,000 will be considered. Negotiations beyond this salary range will be considered for exceptionally qualified candidates. Effective date of appointment is negotiable.

The University of Waterloo is host to the Institute for Quantum Computing. At present, IQC has a complement of 22 faculty members (growing to 33) from the Faculties of Engineering, Mathematics and Science. Interested individuals should upload their application via the faculty application form at: **http://uwaterloo.ca/iqc/positions**.

The application review process will begin on **Dec 1st** and continue until the position is filled.

Washington University in St. Louis

Faculty Positions in Biochemistry and Molecular Biophysics

The Department of Biochemistry and Molecular Biophysics at Washington University School of Medicine invites applications for several tenured/tenure-track faculty positions at the level of Assistant/Associate/Full Professor. Successful candidates will have established a strong record of research. Applicants seeking tenured positions must have a strong record of external funding.

Outstanding individuals working in any area of biochemistry and molecular biophysics are encouraged to apply. The candidate's research should be aimed at addressing fundamental questions related to molecular mechanisms of biological or biomedical relevance. Current research in the department spans a wide range of topics including computational biology, membrane proteins, molecular motors, nucleic acid / protein interactions, protein structure, enzymology and signal transduction. Additional information about the department is available at **http://www.biochem.wustl.edu**. Washington University has a highly interactive research environment with vigorous interdisciplinary graduate and medical scientist training programs.

Applicants should email their curriculum vitae, brief description of their research interests, and contact information of three individuals to the Search Committee at **bmbsearch@biochem.wustl.edu**. The committee will request letters from these individuals as necessary.

Completed applications will be reviewed on a rolling basis, starting immediately. For full consideration, applications should be received by December 1, 2015.

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Monterey Bay Aquarium Research Institute

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Applications for the postdoctoral fellowship program at the Monterey Bay Aquarium Research Institute (MBARI) are currently being accepted. MBARI is dedicated to the development of state-of-the-art instrumentation, systems, and methods for scientific research in the oceans. Ongoing programs in marine robotics, ocean physics, chemistry, geology, and biology as well as information management and ocean instrumentation research and development exist at MBARI. Located in Moss Landing, California at the head of Monterey Canyon, MBARI enjoys convenient access to diverse oceanographic environments. The institute operates research vessels equipped with remotely operated vehicles, autonomous underwater vehicles, and diverse oceanographic equipment. In addition, MBARI operates the MARS seafloor cabled observatory. MBARI is a non-profit oceanographic research institute supported by the David and Lucile Packard Foundation.

Offers will be made to candidates from the fields of biological, chemical, and physical oceanography; marine geology; and ocean engineering. Candidates must be awarded the Ph.D. degree prior to commencing the two-year appointment and start during the 2016 calendar year. Applicants are encouraged to communicate with potential research sponsors at MBARI for guidance on project feasibility, relevance to ongoing research projects, and resource availability (http://www.mbari.org/about/postdoc_mentors.htm).

Application deadline: Wednesday, December 9, 2015

Selected candidates will be contacted in early March 2016.

Application requirements:

1. Curriculum vitae
2. At least three professional letters of recommendation
3. Succinct statement of the applicant's doctoral research
4. Potential research goals at MBARI
5. Supplemental information online form (http://www.mbari.org/oed/jobs/forms/postdoc_form_2016.htm)

Address your application materials to:
MBARI, Human Resources
Job code: Postdocs-2016
7700 Sandholdt Road, Moss Landing, CA 95039-9644

Submit by e-mail to jobs_postdocs@mbari.org (preferred), by mail, or by fax to (831) 775-1620.

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New or recent doctoral recipients with research interests associated with the following are encouraged to submit scholarship applications prior to January 5, 2016.

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Institutes - Each Institute fosters interdisciplinary research addressing critical issues, and we will award a scholarship to support related research: Ocean and Climate Change Institute; Coastal Ocean Institute; Ocean Exploration Institute; Ocean Life Institute

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Further information may be obtained at:
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COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

The 2016 Louisa Gross Horwitz Prize for Biology or Biochemistry

NOMINATIONS

All materials must be written in the English language and submitted electronically at:
http://www.cumc.columbia.edu/research/horwitz-prize

Deadline date: January 22, 2016

Renominations are by invitation only.
Self-nominations are not permitted.

The Louisa Gross Horwitz Prize was established under the will of the late S. Gross Horwitz through a bequest to Columbia University and is named to honor the donor's mother. Louisa Gross Horwitz was the daughter of Dr. Samuel David Gross (1805–1889), a prominent surgeon of Philadelphia and author of the outstanding *Systems of Surgery* who served as president of the American Medical Association.

Each year since its inception in 1967, the Louisa Gross Horwitz Prize has been awarded by Columbia University for outstanding basic research in the fields of biology or biochemistry. The purpose of this award is to honor a scientific investigator or group of investigators whose contributions to knowledge in either of these fields are deemed worthy of special recognition.

The Prize consists of an honorarium and a citation, which are awarded at a special presentation event. Unless otherwise recommended by the Prize Committee, the Prize is awarded annually. Dr. S. Lawrence Zipursky, at the University of California, Los Angeles, was the 2015 awardee.

QUALIFICATIONS FOR THE AWARD

The Prize Committee recognizes no geographical limitations. The Prize may be awarded to an individual or a group. When the Prize is awarded to a group, the honorarium will be divided among the recipients, but each member will receive a citation. Preference will be given to work done in the recent past.

NOMINATIONS SHOULD INCLUDE

1) A summary of the research on which this nomination is based (no more than 500 words).
2) A summary of the significance of this research in the fields of biology or biochemistry (no more than 500 words).
3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
4) A key publication list of up to ten of the nominee's most significant publications relating to the research noted under item 1.
5) A copy of the nominee's curriculum vitae.

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IOWA STATE UNIVERSITY

Structural Biology
Assistant Professor

The Roy J. Carver Department of Biochemistry, Biophysics and Molecular Biology at Iowa State University in Ames, IA has embarked on a transformational expansion of its structural biology research enterprise through a large philanthropic gift from the Roy J. Carver Charitable Trust. This major research initiative in Biomolecular Structure includes long-term investment in new instrumentation, endowed funds for graduate student training, and a series of new faculty hires working at the forefront of any aspect of structural biology.

As part of the faculty positions associated with this initiative, and as part of the interdisciplinary effort across the Iowa State University campus to expand structural biology research, the Department seeks a new tenure-track Assistant Professor to establish a vibrant, externally funded research program of international prominence and participate in graduate and undergraduate teaching.

Applicants should have a Ph.D. or equivalent degree, and research accomplishments indicative of the ability to establish an independent research program of national prominence.

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EDITOR'S PICK

A short-term self-serving legislature

From Roger Taylor

You observe in a Leader article on the scientific illiteracy of politicians that "It is a pity those making the laws don't… try thinking before they act" (7 November, p 5). A pity? I commend your restraint. I also condemn it.

Many years ago I was lobbying on a particular topic. It became clear that the then government was going to enact legislation that was contrary to unequivocal statistical evidence. As an engineer, I believe numbers often convey the truth of a situation. At that time, however, I was young and green in judgement. I later learned that it was the norm for governments to act in this way and that party political point-scoring and incompetence are the true drivers of almost all legislation, bolstered by bigotry, ignorance and short-term self-serving thinking.

We tolerate this, even though it has grievously damaged almost every major public institution, because we are individually resourceful and tolerant and can usually mop up the mess. No amount of personal resource and tolerance, however, will help us or our children and grandchildren when this same irrationality is applied to climate change. Its consequences are truly appalling and, for many, fatal. That is why I condemn your timorous attitude. You know better. You have a respected voice, you should use it.
Meols, Wirral, UK

To read more letters, visit newscientist.com/letters

Psychotherapy and recovered memory

From Fran Poston, UK Council for Psychotherapy

Most registered psychotherapists would probably agree that it is regrettable that mandatory government regulation for practitioners was not enforced in 2012 (10 October, p 3). This failure left the profession loosely regulated, as you state, leaving unregistered practitioners free to choose to call themselves counsellors or psychotherapists.

But to equate this with people being "allowed to mark their own homework" is a generalisation that fails to recognise responsible institutions. The largest registering organisation, UKCP, enforces a registration procedure which is rigorous and demanding, aiming at high professional standards through training, backed up by a robust complaints procedure to ensure safeguarding and quality of service offered to the public.

As you report, recovered memory therapy "has now been almost completely discredited as a therapeutic tool". Any graduate of properly regulated training in counselling or psychotherapy is acutely aware of the dangers of false memory syndrome.

Rather than generalisations, the urgent need is for government to reconsider mandatory regulation of practitioners to weed out those who discredit the profession.
Bungay, Suffolk, UK

Invasive species: an unfair report

From Miguel Clavero, Estación Biológica de Doñana, and Emili García-Berthou, University of Girona

Fred Pearce questioned the way it became generally accepted that invasive species are a significant threat for biodiversity (5 September, p 26). He identified our letter in *Trends in Ecology and Evolution* (*TREE*) in 2005 as one of the main sources and wrote: "The authors told me they had not kept the details of their analysis, nor notes on which species they had included." This implies an unfair accusation of bad scientific practice. In fact, Pearce contacted one of us on 11 October 2013 asking for supplementary information to support the basic statistics given in the *TREE* letter. On 18 October 2013 we were able to send him the whole data set used in the *TREE* letter.

This included the complete taxonomic identification of the 680 animal species considered extinct by the International Union for Conservation of Nature (IUCN) in 2005. The 170 species for which extinction causes could be determined were also clearly identified.

Pearce also wrote that our letter in *TREE* was "just four paragraphs long". We would like to point out that *TREE*, one of the most prestigious journals in the field of ecology, imposes strict word-count limitations. Our letter was not just "a riposte" to a previous paper by Jessica Gurevitch and Dianna Padilla; it showed they had presented incorrect conclusions because of an inappropriate use of the IUCN's Red List database.
Seville and Girona, Spain

Apply branes to the quasar test

From Rainer Dick

I am grateful to *New Scientist* for helping to make more widely known my observation that "branes", as defined by Gia Dvali, Gregory Gabadadze and Massimo Porrati (DGP), can leave traces in the spectra of quasars (24 October, p 30).

The article is generally well researched, but I think it's worth emphasising that the theoretical framework for DGP branes is a well-established and respected generalisation of Einstein gravity, and one of the most important contributions to the development of gravitational theory since the inception of general relativity 100 years ago.

If you accept the premise of DGP brane theory that matter can live on a four-dimensional "submanifold" in a higher-dimensional space-time, then it is a natural conclusion that several DGP branes can move through the same higher-dimensional space-time, and their possible collisions or overlaps can leave cosmological signatures. My contribution was the observation that brane overlap can occur and that distortions of redshift signals follow as a testable prediction.
Saskatoon, Canada

When moral dilemmas aren't

From Shane Budden

Dan Jones's article on morality was interesting, but would have been far more compelling if he had dealt with moral dilemmas that had no grey area, actual or perceived (26 September, p 36). For example, while most *New Scientist* readers (me included) accept that the best explanation of current climate data is that the planet is warming due to human activity, there are plenty of people, misguided though they surely are, who do not accept that humans have a significant impact on our climate.

For some, the refusal to do anything about it is due to a belief that such action would be futile, as well as damaging to the economy and their way of life. It has little to do with an inability to behave in a moral way.

Psychologist Paul Bloom makes a big call when he identifies empathy as being the reason we care more about the little girl in the well than about the millions

"We're right behind you, mate. Well, actually, we're safely back on board"

Jacqui Chaplin appreciates David Jacoby's free-diving mission to tag hammerhead sharks (14 November, p 12)

affected by climate change. An equally valid explanation is that on an individual level we can do something about the little girl, but without wide cooperation our efforts to combat climate change will be largely in vain.
Kenmore, Queensland, Australia

Climate chaos by any other name

From Jane Lambert
Psychologist Robert Gifford identifies 33 psychological barriers stopping us from tackling climate change (11 July, p 28). But what about nominative determinism? Maybe we haven't taken action on global warming because the word "warming" has positive connotations for the inhabitants of temperate regions, where the world's decision-makers tend to be. When global warming first hit the headlines in the UK, it was regarded as an exciting development.

One newspaper even printed an artist's impression of what your suburban home might soon look like, with bunches of grapes growing around the front door. The word "warming" might be technically accurate and might even have been chosen to avoid alarmism. But a shot of alarmism might now be useful. So how about replacing the expression "global warming" with the clearer "global overheating"?
Cambridge, UK

Acceptable to whom, politically?

From Bryn Glover
Michael Le Page simply asserts that it would be "politically unacceptable" to "curb the lifestyles of the jet-setting elite", without further justification (17 October, p 8). Unacceptable to whom? Certainly not to me.

History offers many examples of direct community action to curb the antisocial activities of the few, when persuasion and pleas for voluntary restraint have failed. Two hundred years ago, in the face of enormous opposition from powerful vested interests, the slave trade was abolished.

More recently, in the face of opposition from those who could afford to burn coal fires in central London, clean air legislation was enacted. If those who happen to have acquired vast fortunes refuse to quit activities that prejudice the quality of life of the rest of humanity, then humanity surely has the right to "curb" them, as Le Page puts it.
Kirkby Malzeard, North Yorkshire, UK

Tax and dividend carbon plan

From William Hughes-Games
Your leader article on carbon pricing (17 October, p 5) sounds very much like a proposal by climate scientist James Hansen: see for example his description at bit.ly/TaxAndDividend. Beyond national pricing, he suggests taxing fossil fuel as it crosses borders, if the exporting country doesn't already tax it.

No fossil-fuel-exporting country will want to miss out on this lucrative revenue stream, so all will rush to tax their own fossil fuel. Oh, and Hansen says that an equal portion of every cent collected should be sent to every registered taxpayer by virtually free bank transfer.
Waipara, New Zealand

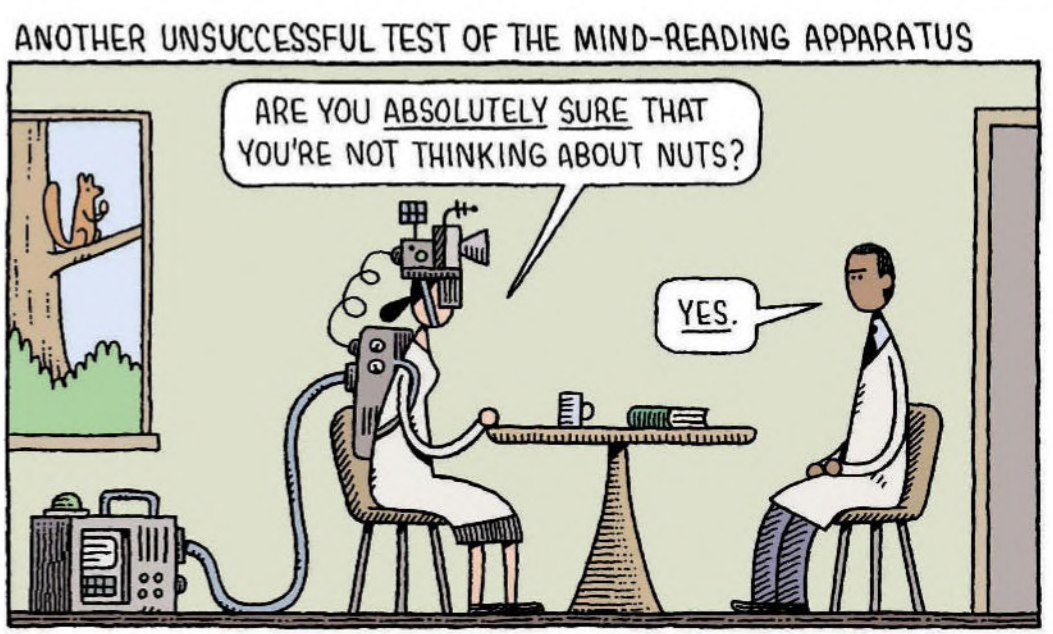
Moral compass points awry

From Jock Webb
It is tragic that a number of people in California have been killed or rendered homeless by fires (26 September, p 6). But the loss of forest is, surely, also catastrophic. Has the moral compass hit a magnetic reversal?

Australian media are also awful in this regard. "No property was lost," they say, smiling. I am happy to hear it, but what about the 5000 hectares of destroyed bushland and attached ecology?

And what compass rules the extraordinary proposals for gene editing and drugs to govern our morals (p 36)? I am sure I hear Aldous Huxley's ghost rattling his chains and proffering his *Brave New World*. Surely no one believes they know all the consequences. Genes don't always do what they are supposed to: editing might result in unexpected events.
Narromine, New South Wales, Australia

TOM GAULD



For the record

■ **A letter about educational measurement was in fact written by Russell Waugh (31 October).**

Letters should be sent to:
Letters to the Editor, New Scientist, 110 High Holborn, London WC1V 6EU
Email: letters@newscientist.com

Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. Reed Business Information reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

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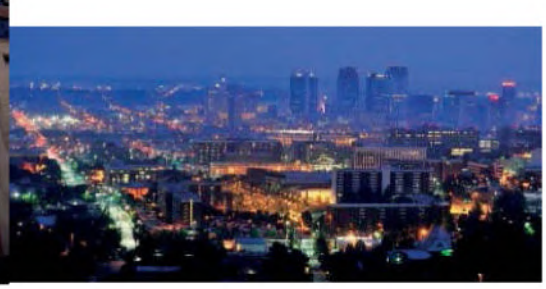


For complete program information, including deadlines, please visit www.bwfund.org

Grant Programs

BIOMEDICAL SCIENCES

Career Awards for Medical Scientists: Five-year awards for physician scientists provide $700,000 to bridge advanced postdoctoral/fellowship training and the early years of faculty service. This award addresses the on-going problem of increasing the number of physician scientists and will help facilitate the transition to a career in research.

Collaborative Research Travel Grants: Provide up to $15,000 in support for interdisciplinary biomedical researchers from degree-granting institutions to travel to a laboratory to acquire a new research technique or to facilitate collaboration.

DIVERSITY IN SCIENCE

Postdoctoral Enrichment Program: Provides $50,000 over three years to support the development of underrepresented minority postdoctoral fellows in biomedical research.

INFECTIOUS DISEASES

Investigators in the Pathogenesis of Infectious Disease: Five-year awards provide $500,000 for opportunities for accomplished investigators at the assistant professor level to study infectious disease pathogenesis, with a focus on the intersection of human and microbial biology. The program is intended to shed light on the overarching issues of how human hosts handle infectious challenge.

INTERFACES IN SCIENCE

Career Awards at the Scientific Interface: Five-year awards provide $500,000 to bridge advanced postdoctoral training and the early years of faculty service. These awards are intended to foster the early career development of researchers with backgrounds in the physical/mathematical/computational/engineering sciences whose work addresses biological questions. BWF has moved to a self-nomination format for this award.

POPULATION AND LABORATORY BASED SCIENCES

Institutional Program Unifying Population and Laboratory Based Sciences: Five-year awards provide $2.5 million to unite population-level and laboratory-based biological sciences. The award supports the training of researchers working between existing research concentrations in population approaches to health and in basic biological sciences. The goal is to establish interdisciplinary training programs by partnering researchers working in disparate environments and intellectual frameworks.

REGULATORY SCIENCE

Innovation in Regulatory Science Awards: Provides up to $500,000 over five years to academic investigators who are addressing research questions that will lead to innovation in regulatory science, with ultimate translation of those results into improving the regulatory process. These awards are intended to provide support for academic researchers developing new methodologies or innovative approaches in regulatory science that will ultimately inform the regulatory decisions the Food and Drug Administration (FDA) and others make.

REPRODUCTIVE SCIENCE

Preterm Birth Initiative: Provides $600,000 over a four-year period to bring together a diverse interdisciplinary group with the more traditional areas of parturition research to address the scientific issues related to preterm birth.

SCIENCE EDUCATION

Career Awards for Science and Mathematics Teachers: Five-year awards provide $175,000 to eligible science or mathematics teachers in the North Carolina public primary and secondary schools. The purpose of this award is to recognize teachers who have demonstrated solid knowledge of science or mathematics content and have outstanding performance records in educating children. The award is a partnership between the North Carolina State Board of Education and BWF.

Student Science Enrichment Program: Three-year awards provide up to $180,000 to North Carolina nonprofit organizations, including public/private schools, universities, colleges, and museums. This program supports creative inquiry-based science enrichment activities that occur outside the typical school day for K-12 students. The program's goals are to nurture students' enthusiasm about science, expose them to the excitement of scientific discovery, and interest them in pursuing careers in research or a variety of other careers in science.

Promoting Innovation in Science and Mathematics: Awards provide teachers with funding for materials, equipment, and training to conduct hands-on, inquiry-based science and mathematics projects in North Carolina public schools.

The Burroughs Wellcome Fund is a private foundation located in Research Triangle Park, North Carolina. Find out more at **bwfund.org**

BURROUGHS WELLCOME FUND

PAUL MCDEVITT

HEAPS of dirty dishes piled in the sink can be a source of domestic tension. The good news from Florida State University in Tallahassee is that washing them up can relieve that stress – if you do it mindfully.

A press release helpfully defines mindfulness as "a meditative method of focusing attention on the emotions and thoughts of the present moment". Meditation may be the last thing to spring to mind when contemplating an unwanted task. However, the Florida State team report in the journal *Mindfulness* that students who focused on the smell of the soap, the warmth of the water and the feel of the detergent experienced 27 per cent less nervousness and 25 per cent more mental inspiration. Those who didn't, saw no benefit.

Feedback, though, enjoys the soft, pleasant hum of the dishwasher.

HOW do I dislike thee, let me count the ways. Han Alves and colleagues at the University of Cologne explore the quirks of friendship in a paper titled: "My friends are all alike – the relation between liking and perceived similarity in person perception." The authors discover that although people tend to know their friends in more detail than their enemies, positive impressions are less diverse than negative ones. They conclude – as most politicians have surely realised already – that "there are only a few ways to be liked, but many ways to be disliked".

MORE loving feelings: the twilight years offer no shortage of romance, as evidenced by a report into the sex lives of nursing homes residents. The *Journal of Post-Acute and Long-Term Care Medicine* reports that over 70 per cent of nursing home directors surveyed had dealt with issues arising from residents' sexual activities.

But perhaps most surprisingly, one in eight require family members to approve sexual activity for a resident, even if they have no cognitive impairment. The authors write that clear guidelines, communicated to the resident and their family, "would enable residents to engage in sexual activity with understanding and support rather than hiding". Openness is sensible but, as any teenager sneaking paramours into their bedroom knows, far less exciting.

IT'S often quipped that summer is the best day of the year in Scotland, and the most recent season was indeed wet and cold. Residents may take consolation in the dramatic effect this inclement weather has had on local pest species: the *Courier & Advertiser* newspaper reports that midge populations have dropped an incredible "two million per cent".

Nigel Henbest worries that "the age-old annoyance of midge bites in Scotland is to be compounded by an even vaster horde of anti-matter midges". Feedback notes that the *Courier* also conveys a warning from the Scottish Midge Forecast that the mild autumn has produced a rare "third hatch" of the biting flies; this could make for an explosive combination.

YET more trouble with girls: in *The Telegraph*, columnist Cristina Odone wants to know why her 12-year-old daughter should be forced to study science, "just to appease feminists".

Girls, we are told, are being pressured into science, technology, engineering and maths classes to make up a shortfall of women in these industries – an argument that, were it true, would only demonstrate how ineffective such pressure is.

Odone, who studied history at the University of Oxford, is keen to illustrate that the life scientific is no guarantee of fulfilment. She points out that "JK Rowling strikes me as a lot happier and more successful than Alan Turing, the tortured mathematics genius who took his own life". Truly is mathematics the dismal science.

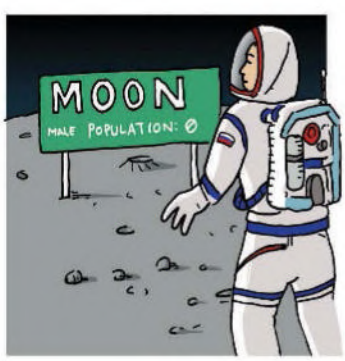
Amid all this hullabaloo, Feedback can't help but note that the reason Odone's daughter is forced to study science is rather less sinister: it is a compulsory subject for all students under 16, regardless of their gender.

RUSSIA is aiming for the stars, but finds itself weighed down by more base concerns. The Institute of Biomedical Problems (IBP) plans to seal six cosmonauts in a wood-panelled isolation chamber for eight days, to simulate a trip to the moon and back.

The fact that all six are women didn't escape many at the press conference. The AFP reports that the crew found themselves fielding questions on how they would survive a week without men or make-up.

If the all-female crew was an attempt to shore up the equality credentials of the Russian space programme – which has sent only four women into space in its history – IBP's director Igor Ushakov didn't get the memo.

"I'd like to wish you a lack of conflicts," he told the crew, "even though they say that in one



kitchen, two housewives find it hard to live together." Russia's prospective cosmonauts could be forgiven for thinking eight days of isolation from the rest of the world isn't nearly long enough.

THOSE with a nut allergy and a nervous disposition should look away now. Subramaniam Divakaran is left feeling paranoid after reading the cryptic warning attached to his rossogolla (an Indian dessert of paneer balls in sweet syrup). "Product made in nut free areas," it tells him, before adding: "but nuts elsewhere."

"Do not take if you are pregnant": advice spotted by Steve Etzel on a pack of Prolia – a treatment for postmenopausal osteoporosis

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Lunar loser

If the moon were to disappear, how long would it take for the tides to stop?

■ The good news is that it would take a very long time for the tides to stop – until Earth stops spinning and has only one face pointing at the sun, or the oceans boil away.

The reason is that there are two celestial bodies that cause tides on Earth: the moon and the sun. The strength of the sun's gravitational effect on tides is slightly less than half that of the moon. The two bodies can either act together or against each other, depending on where the moon is in its orbit.

The phenomenon of the spring tide is produced when the sun and moon line up, giving exceptionally high and low tides. Neap tides – when there is the smallest difference between high and low water – occur when the tide-generating force of the sun opposes that of the moon. The magnitude of tides produced in the seas of a moonless Earth would only be slightly less than the current weakest neap tide.
Peter Skelly
Bedford, UK

■ If the moon suddenly disappeared, the main force that causes the tides would stop immediately (or just after the time it takes for gravity to travel from the moon to Earth – about 1.5 seconds). But because the seas would be piled up on two opposite parts of Earth, and would be lower in the belt between those parts, the water would start to oscillate. Initially it would flow from the two "hills" of sea towards the low-tide area, where it would pile up again. Then the water would stop and start flowing the other way.

"Because the seas would be piled up on two parts of Earth, the water would start to oscillate"

This oscillation would in theory go on forever, but in reality would become more chaotic through friction and the interference of the land, and would diminish in amplitude over time from hydraulic drag on the seabed.
Eric Kvaalen
Les Essarts-le-Roi, France

Getting off the ground

What is holding back the development of geothermal energy? There must be an awful lot of energy down there.

■ Geothermal energy for heating makes a great deal of sense in cold climates, and localised "district heating" systems that use it have been around for centuries.

If you want to generate electricity, then it's best to find the hottest water you can. Very hot water is easily accessible in volcanic regions, but in most areas drilling and fracking are needed to access the heat deep in Earth's crust. This becomes expensive, especially if you want water hot enough to drive state-of-the-art power plants that use steam at 600 °C. Typically water from the ground is much cooler than if we used coal, oil or gas to make steam.

Geothermal power will therefore always be expensive compared with fossil fuels, but perhaps carbon dioxide emissions will drive those out of fashion.
Hugh Hunt
Trinity College
Cambridge University, UK

This week's questions

WINDBLOWN
Our local community turbine rotates at a constant speed of 39 revolutions per minute. What is the mechanism that allows greater power to be generated in strong winds, in terms I can explain to my grandchildren?
Glyn Hicks
Fishguard, Pembrokeshire, UK

CREATING A BUZZ
If humans stopped taking honey from all beehives, how would this affect the world of bees?
Larry Curle
Huntingdon, UK

UNDER PRESSURE?
I read in *New Scientist* that the pressure at Earth's core is 3.6 million atmospheres. I would expect the pressure there to be zero, because it arises from gravity, and this must be zero at the core since the pull of the surrounding matter is equal in all directions. Can someone get to the bottom of this?
Shawn Charland
Ottawa, Ontario, Canada

JOURNEY'S END
If an alien race sent a Voyager-type probe towards us, would we be able to detect it?
Paul Manson
Aberdeen, UK

BREWED AT ALTITUDE
How does atmospheric pressure affect the boiling point of water?
Christopher Webster
Kista, Sweden

SEAL MEAL
We hear that polar bears are under threat from climate change and may starve as the world's ice melts. This is because it is difficult for them to venture onto thinning sea ice to find their favoured food – seals. But presumably the seals will still breed somewhere. Where is that, and will it be accessible to polar bears?
Clive Wilkinson
Townsville, Queensland, Australia

AERIAL DRONE
Why do light aircraft with piston engines make so much noise, even when they are far away? They can be very intrusive, especially in secluded landscapes such as Dartmoor National Park. Are they fitted with silencers like road vehicles? And if not, why not?
Duncan Hutchinson
Newton Abbot, Devon, UK

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